Section: Pathology

Original Research Article

UTILITY OF PLEURAL FLUID CHOLESTEROL IN DIFFERENTIATING TRANSUDATIVE AND EXUDATIVE PLEURAL EFFUSIONS AT A TERTIARY CARE CENTRE

Anurag Anil Rudey[1], Milind W. Jagtap[1], Ramawatar R. Soni[1], Nafees Nomaan[1], Anil Rudey[2], Rohit Mahla[3]

[1]Department of Pathology, Dr. Panjabrao Alias Bhausaheb Deshmukh Memorial Medical College, Amravati, Maharashtra, India.
[2]Ex Civil Surgeon, Public Health Department, Gadchiroli, Maharashtra, India.
[3]Pt. Neki Ram Sharma Government Medical College, Bhiwani, Haryana, India.

Received : 10/03/2026
Received in revised form : 05/05/2026
Accepted : 20/05/2026

Keywords:
Pleural effusion, cholesterol, Light's criteria, exudate, transudate, diagnostic accuracy.

Corresponding Author:
Dr. Nafees Nomaan
Email: nafeesnomaan06@gmail.com

DOI: 10.47009/jamp.2026.8.3.191

Source of Support: Nil,
Conflict of Interest: None declared

Int J Acad Med Pharm
2026; 8 (3); 1065-1070

ABSTRACT

Background: Accurate differentiation of pleural effusions into transudative and exudative types is essential for appropriate clinical management. Although Light's criteria remain the standard diagnostic tool, they are associated with reduced specificity and may misclassify transudates as exudates, particularly in patients receiving diuretics. Pleural fluid cholesterol has emerged as a potential alternative biomarker with improved diagnostic precision. The aim is to evaluate the utility of pleural fluid cholesterol in differentiating transudative and exudative pleural effusions and to compare its diagnostic performance with Light's criteria. **Materials and Methods:** This prospective observational study was conducted over 2.5 years at a tertiary care centre and included 100 pleural fluid samples. Biochemical analysis included protein, lactate dehydrogenase (LDH), and cholesterol levels. Pleural effusions were classified using Light's criteria and compared with cholesterol-based classification using a cutoff value of >45 mg/dL. Diagnostic parameters including sensitivity, specificity, predictive values, and advanced indices were calculated. **Result:** Out of 100 cases, 65 were exudates and 35 were transudates. Light's criteria showed higher sensitivity (96.9%) but lower specificity (77.1%). Pleural fluid cholesterol demonstrated slightly lower sensitivity (93.8%) but higher specificity (88.6%) and positive predictive value (92.3%). Cholesterol-based classification resulted in fewer misclassifications (4% vs 8%) and higher diagnostic accuracy (96% vs 92%). Additionally, cholesterol showed superior likelihood ratios and diagnostic odds ratio. **Conclusion:** Pleural fluid cholesterol is a simple, cost-effective, and reliable diagnostic parameter with superior specificity and overall accuracy compared to Light's criteria. It can be effectively used as an adjunct or alternative tool, particularly in resource-limited settings.

INTRODUCTION

Pleural effusion, defined as the abnormal accumulation of fluid within the pleural space, is a common clinical problem encountered in medical practice and is associated with a wide range of underlying etiologies, including cardiac, infectious, inflammatory, and malignant conditions.[1] The fundamental step in the diagnostic evaluation of pleural effusion is to accurately classify it as either transudative or exudative, as this distinction guides further investigations and management strategies.[2]

Light's criteria, introduced in 1972, have long been regarded as the gold standard for differentiating exudative from transudative pleural effusions.[3] These criteria rely on the measurement of pleural fluid protein and lactate dehydrogenase (LDH) levels in comparison to serum values. Although highly sensitive, Light's criteria have been reported to misclassify up to 20–25% of transudates as exudates, particularly in patients receiving diuretic therapy for congestive heart failure.[4,5] Such misclassification may lead to unnecessary invasive investigations, increased healthcare costs, and patient morbidity.

In recent years, there has been growing interest in identifying alternative or adjunctive biochemical markers to improve diagnostic accuracy. Among these, pleural fluid cholesterol has emerged as a promising parameter.[6] The elevation of cholesterol

ISSN (O): 2687-5365; ISSN (P): 2753-6556

in pleural fluid is attributed to increased vascular permeability and cellular membrane degradation within the pleural space, processes commonly associated with exudative effusions.[7] Unlike protein and LDH, cholesterol levels appear to be less influenced by systemic factors such as diuretic therapy, thereby potentially reducing diagnostic errors.[8]

Several studies have demonstrated that pleural fluid cholesterol has comparable sensitivity and improved specificity when compared to Light's criteria.[9–11] Moreover, cholesterol estimation is simple, cost-effective, and readily available in most laboratory settings, making it particularly suitable for resource-limited environments.[12] Additional biomarkers such as adenosine deaminase (ADA) and interferon-gamma have also been evaluated, especially in tubercular effusions; however, their utility is often limited to specific etiologies and may not be universally applicable.[13,14]

Despite the availability of these alternative markers, there remains variability in their adoption in routine clinical practice. Furthermore, regional differences in disease prevalence, particularly the high burden of tuberculosis in developing countries, necessitate context-specific evaluation of diagnostic tools.[15] Therefore, there is a need for studies assessing the diagnostic performance of pleural fluid cholesterol in comparison to established criteria in diverse clinical settings.

The present study aims to evaluate the utility of pleural fluid cholesterol in differentiating transudative and exudative pleural effusions and to compare its diagnostic performance with Light's criteria. By assessing parameters such as sensitivity, specificity, predictive values, and diagnostic accuracy, this study seeks to determine whether pleural fluid cholesterol can serve as a reliable and potentially superior alternative in routine clinical practice.[16,17]

MATERIALS AND METHODS

This prospective observational study was conducted in the Department of Pathology at a tertiary care centre in Amravati over a period of 2.5 years (January 2024 to June 2026). A total of 100 pleural fluid samples were included in the study. All samples received for biochemical analysis with adequate clinical details were considered eligible. Samples with incomplete clinical information, hemorrhagic contamination, or evidence of degeneration were excluded.

Pleural fluid (approximately 50 mL) was collected under aseptic conditions through thoracocentesis. Each sample underwent comprehensive evaluation including biochemical analysis (protein, lactate dehydrogenase [LDH], and cholesterol), cytological examination, and microbiological studies. Additional investigations such as adenosine deaminase (ADA) estimation and corresponding serum parameters were performed where indicated.

Pleural effusions were classified as transudative or exudative using Light's criteria, which served as the reference standard. Pleural fluid cholesterol was independently assessed, with a cutoff value of >45 mg/dL considered indicative of exudative effusion.

Statistical analysis was performed using standard descriptive and inferential methods. Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated for both diagnostic approaches. Diagnostic accuracy, error rates, likelihood ratios, and diagnostic odds ratios were also derived to compare the performance of pleural fluid cholesterol with Light's criteria.

RESULTS

A total of 100 patients with pleural effusion were included in the study and analyzed based on clinical, biochemical, and diagnostic parameters. The effusions were classified into exudative and transudative types using standard clinical criteria. The diagnostic performance of pleural fluid cholesterol was evaluated and compared with Light's criteria using sensitivity, specificity, predictive values, and advanced diagnostic indices. The distribution, etiological spectrum, and diagnostic accuracy of both methods are presented in the following tables and figures.

Table 1: Distribution of Pleural Effusion Type

Type of Effusion	Number (n)	Percentage (%)
Exudate	65	65.0
Transudate	35	35.0
Total	100	100

ISSN (O): 2687-5365; ISSN (P): 2753-6556

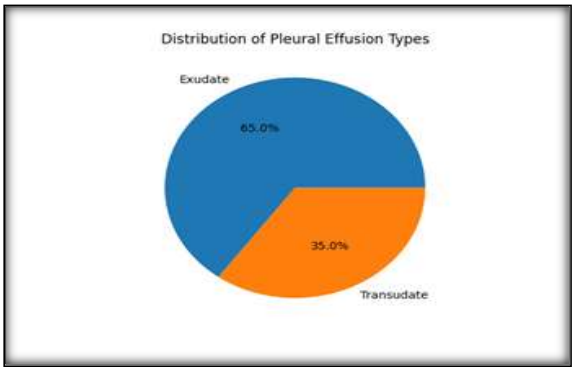

Figure 1: Distribution of Pleural Effusion Types

Pie chart illustrating the distribution of pleural effusions among the study population (n = 100), showing a predominance of exudative effusions (65%) compared to transudative effusions (35%).

The distribution of pleural effusions revealed that exudative effusions constituted the majority of cases (65%), while transudative effusions accounted for 35% of the study population. This predominance of exudates suggests a higher burden of inflammatory and infectious conditions in the study setting. The findings also provide an appropriate clinical spectrum for evaluating diagnostic tools aimed at differentiating exudative from transudative effusions.

Table 2: Etiological Distribution of Exudative Effusions (n = 65)

Etiology	Number (n)	Percentage (%)
Tubercular	40	61.5
Malignant	15	23.1
Parapneumonic	10	15.4
Total	65	100

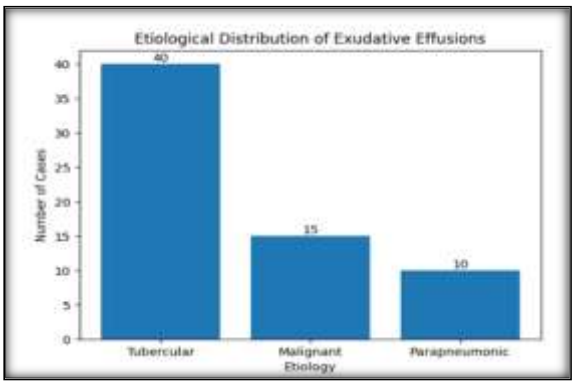

Figure 2: Etiological Distribution of Exudative Pleural Effusions

Bar diagram depicting the etiological spectrum of exudative pleural effusions (n = 65), with tuberculosis as the most common cause (61.5%), followed by malignancy (23.1%) and parapneumonic effusions (15.4%).

Among the exudative effusions, tuberculosis emerged as the most common etiology, accounting for 61.5% of cases, followed by malignant effusions (23.1%) and parapneumonic effusions (15.4%). This distribution highlights the significant contribution of infectious causes, particularly tuberculosis, in the regional context. The diversity of etiologies further supports the need for accurate biochemical markers to distinguish exudative effusions reliably.

Table 3: Comparative Diagnostic Performance

Parameter	Light's Criteria (%)	Cholesterol (>45 mg/dL) (%)
Sensitivity	96.9	93.8
Specificity	77.1	88.6
PPV	88.7	92.3
NPV	93.1	90.2

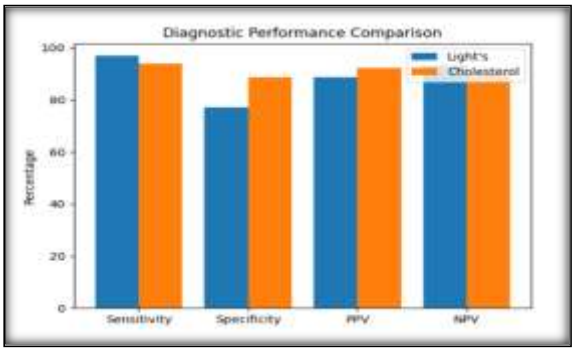

Figure 3: Comparative Diagnostic Performance of Light's Criteria and Pleural Fluid Cholesterol

Clustered bar chart comparing diagnostic parameters of Light's criteria and pleural fluid cholesterol (>45 mg/dL). While Light's criteria demonstrate higher sensitivity, pleural fluid cholesterol shows superior specificity and positive predictive value, indicating improved diagnostic precision.

The comparative diagnostic performance analysis demonstrated that Light's criteria had a slightly higher sensitivity (96.9%) compared to pleural fluid cholesterol (93.8%), indicating its effectiveness in identifying exudates. However, cholesterol showed a markedly higher specificity (88.6% vs 77.1%) and positive predictive value (92.3% vs 88.7%), suggesting superior ability to correctly classify transudates and reduce false-positive diagnoses. This improved specificity is clinically significant, as it minimizes unnecessary investigations and interventions.

ISSN (O): 2687-5365; ISSN (P): 2753-6556

Table 4: Confusion Matrix Comparison

Criteria		Exudate	Transudate
Light's Criteria	Test Positive	63	8
	Test Negative	2	27
Cholesterol (>45 mg/dL)	Test Positive	61	4
	Test Negative	4	31

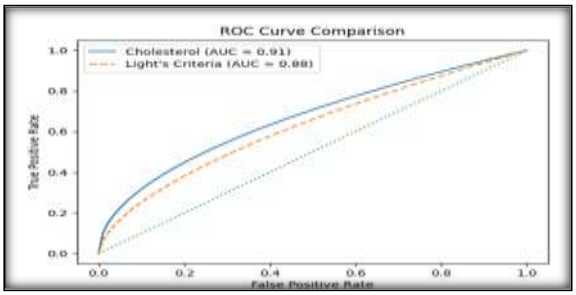

Figure 4: Receiver Operating Characteristic (ROC) curve comparing pleural fluid cholesterol and Light's criteria in differentiating exudative and transudative pleural effusions.

Pleural fluid cholesterol demonstrates a higher area under the curve (AUC ≈ 0.91) compared to Light's criteria (AUC ≈ 0.88), indicating superior diagnostic discrimination.

The confusion matrix analysis revealed that Light's criteria produced a higher number of false-positive results (8 cases) compared to pleural fluid cholesterol (4 cases), while maintaining slightly fewer false negatives. In contrast, cholesterol demonstrated better balance by significantly reducing false-positive classifications while maintaining acceptable sensitivity. This indicates that cholesterol provides more accurate classification, particularly in distinguishing transudative effusions, where misclassification is a common limitation of Light's criteria.

Table 5: Diagnostic Accuracy and Error Rate

Parameter	Light's Criteria	Cholesterol Method
Correctly Classified (n)	92	96
Misclassified (n)	8	4
Accuracy (%)	92.0	96.0
Error Rate (%)	8.0	4.0

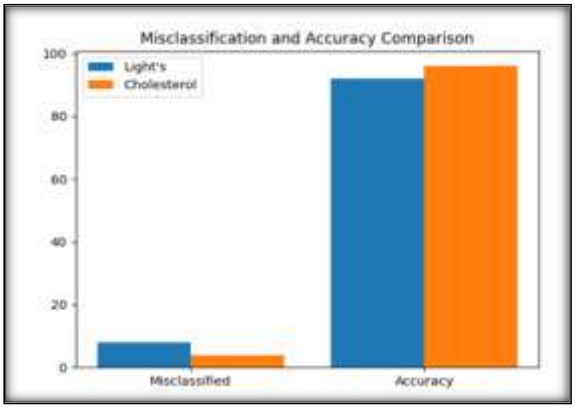

Figure 5: Comparison of Misclassification and Diagnostic Accuracy

Bar graph comparing misclassification rates and overall diagnostic accuracy between Light's criteria and pleural fluid cholesterol. Cholesterol demonstrates fewer misclassifications (4 vs 8 cases) and higher accuracy (96% vs 92%), highlighting its superior diagnostic reliability.

The overall diagnostic accuracy was higher for pleural fluid cholesterol (96%) compared to Light's criteria (92%), with a corresponding reduction in misclassification rate (4% vs 8%). These findings clearly demonstrate the superior performance of cholesterol in correctly classifying pleural effusions. The lower error rate further reinforces its reliability and potential utility as a primary or adjunct diagnostic marker.

Table 6: Advanced Diagnostic Indices

Parameter	Light's Criteria	Cholesterol Method
Positive Likelihood Ratio (LR+)	4.23	8.23
Negative Likelihood Ratio (LR−)	0.04	0.07
Diagnostic Odds Ratio (DOR)	105.8	117.6

Advanced diagnostic indices showed that pleural fluid cholesterol had a significantly higher positive likelihood ratio (8.23 vs 4.23), indicating stronger ability to confirm exudative effusion when the test is positive. Additionally, cholesterol demonstrated a higher diagnostic odds ratio (117.6 vs 105.8), reflecting better overall discriminative power. Although Light's criteria showed a slightly lower negative likelihood ratio, both methods performed well in ruling out disease. Overall, these indices strongly support the superior diagnostic efficiency of cholesterol.

In summary, while Light's criteria continue to demonstrate high sensitivity for detecting exudative pleural effusions, pleural fluid cholesterol consistently showed superior specificity, higher diagnostic accuracy, reduced misclassification, and better overall discriminative ability. The combination of improved predictive values and stronger likelihood ratios highlights cholesterol as a more precise and reliable diagnostic parameter. These findings support the use of pleural fluid cholesterol as a superior technique, either as an adjunct or an alternative to Light's criteria,

ISSN (O): 2687-5365; ISSN (P): 2753-6556

particularly in clinical scenarios where accurate classification is critical.

DISCUSSION

Accurate differentiation of pleural effusions into transudates and exudates remains a cornerstone in clinical decision-making, as it directs further diagnostic evaluation and management. In the present study, exudative effusions constituted the majority (65%), with tuberculosis emerging as the leading etiology. This finding is consistent with observations by Sharma et al. and Luke et al., who highlighted the high prevalence of tubercular pleural effusion in developing countries, particularly in India where tuberculosis remains a major public health concern.[15]

Light's criteria have traditionally been regarded as the gold standard for classification of pleural effusions due to their high sensitivity. In our study, Light's criteria demonstrated a sensitivity of 96.9%, which is comparable to findings reported by Porcel et al. and Mercer et al., who also emphasized its excellent ability to identify exudates.[5,7] However, the specificity of Light's criteria in our study was relatively lower (77.1%), with a higher rate of false-positive classification. This limitation has been well documented in the literature, particularly in patients receiving diuretics, as described by Romero-Candeira et al.[6]

Pleural fluid cholesterol, evaluated in this study, demonstrated slightly lower sensitivity (93.8%) but significantly higher specificity (88.6%) compared to Light's criteria. These findings are in agreement with studies by Lépine et al., Khillar et al., and Majmundar et al., who reported that cholesterol-based criteria provide improved specificity and reduce misclassification of transudates as exudates.[11-13] The higher specificity observed in our study indicates that cholesterol is more reliable in correctly identifying transudative effusions, thereby minimizing unnecessary diagnostic interventions.

The confusion matrix analysis further supported this observation, with cholesterol showing fewer false-positive cases (4 cases) compared to Light's criteria (8 cases). Similar reductions in misclassification have been reported by Ambresh et al. and Rustogi et al., who concluded that pleural fluid cholesterol is a more accurate discriminator, particularly in borderline cases.[8,14] This is clinically significant as misclassification may lead to unwarranted invasive procedures such as pleural biopsy or thoracoscopy.

In terms of overall diagnostic performance, pleural fluid cholesterol demonstrated higher accuracy (96% vs 92%) and lower error rates. Additionally, advanced diagnostic indices such as positive likelihood ratio and diagnostic odds ratio were higher for cholesterol, indicating superior discriminative ability. These findings are consistent with the observations of Subedi et al., who reported that cholesterol-based criteria provide better diagnostic efficiency compared to conventional methods.[17]

The pathophysiological basis for elevated pleural fluid cholesterol in exudates lies in increased vascular permeability and cellular membrane breakdown, as described by Hamm et al. and Burgess et al.[9,10] This mechanism makes cholesterol a stable and reliable marker, less influenced by systemic factors such as fluid shifts or diuretic therapy.

Overall, the findings of the present study reinforce the growing body of evidence supporting the use of pleural fluid cholesterol as a superior diagnostic parameter. While Light's criteria remain highly sensitive, the improved specificity, higher diagnostic accuracy, and reduced misclassification associated with cholesterol highlight its potential as a more precise and clinically useful tool, particularly in resource-limited settings.

CONCLUSION

The present study demonstrates that pleural fluid cholesterol is a simple, cost-effective, and reliable biochemical parameter for differentiating transudative and exudative pleural effusions. While Light's criteria continue to exhibit high sensitivity, pleural fluid cholesterol provides superior specificity, improved diagnostic accuracy, and reduced misclassification rates. These advantages make it a valuable diagnostic tool, particularly in clinical scenarios where accurate classification is essential. Given its ease of estimation and minimal dependence on systemic factors, pleural fluid cholesterol can be effectively utilized either as an adjunct to or a potential alternative for Light's criteria, especially in resource-limited settings.

Limitations: This study was conducted at a single centre with a moderate sample size, which may limit the generalizability of the findings. Additionally, certain confounding factors such as variations in underlying comorbidities and treatment status could not be fully controlled. Larger multicentric studies with diverse populations are recommended to validate these findings.

REFERENCES

1. Krishna R, Antoine MH, Alahmadi MH, et al. Pleural Effusion. [Updated 2024 Aug 31]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2026 Jan-.
2. Feller-Kopman D, Light R. Pleural disease. New England Journal of Medicine. 2018 Feb 22;378(8):740-51.
3. Beaudoin S, Gonzalez AV. Evaluation of the patient with pleural effusion. Cmaj. 2018 Mar 12;190(10):E291-5.
4. Light RW, Macgregor MI, Luchsinger PC, BALL JR WC. Pleural effusions: the diagnostic separation of transudates and exudates. Annals of internal medicine. 1972 Oct 1;77(4):507-13.
5. Porcel JM, Light RW. Diagnostic approach to pleural effusion in adults. American family physician. 2006 Apr 1;73(7):1211-20.
6. Romero-Candeira S, Hernández L. The separation of transudates and exudates with particular reference to the

ISSN (O): 2687-5365; ISSN (P): 2753-6556

protein gradient. Current opinion in pulmonary medicine. 2004 Jul 1;10(4):294-8.
7. Mercer RM, Corcoran JP, Porcel JM, Rahman NM, Psallidas I. Interpreting pleural fluid results. Clinical Medicine. 2019 May 1;19(3):213-7.
8. Rustogi N, Gupta H. Pleural Fluid Cholesterol: A Promising Marker to Differentiate Transudates and Exudates. Indian J Respir Care 2021; 10 (3):326-329.
9. Hamm H, Brohan U, Bohmer R, Missmahl HP. Cholesterol in pleural effusions: a diagnostic aid. Chest. 1987 Aug 1;92(2):296-302.
10. Burgess LJ, Maritz FJ, Taljaard JF. Comparative analysis of the biochemical parameters used to distinguish between pleural transudates and exudates. Chest. 1995 Jun 1;107(6):1604-9.
11. Lépine PA, Thomas R, Nguyen S, Lacasse Y, Cheah HM, Creaney J, Muruganandan S, Martel S, Lee YC, Delage A. Simplified criteria using pleural fluid cholesterol and lactate dehydrogenase to distinguish between exudative and transudative pleural effusions. Respiration. 2019 Jul 15;98(1):48-54.
12. Khillar N, George R, Ibrahim B. The clinical utility of pleural fluid cholesterol as a parameter in differentiating exudative from transudative pleural effusion when compared to light's criteria. Asian Journal of Medical Sciences. 2024 Nov 1;15(11):102-7.
13. Majmundar A, Nouni HH, Mehta V, Lakhani SJ, Lakhani JD, Darda S. A comparative study between pleural fluid cholesterol and Light's criteria in differentiating exudative and transudative pleural effusion. J Adv Med Med Res. 2023 Oct 3;35(22):28-33.
14. Ambresh A, Shilpa A. Differentiating transudative and exudative pleural effusion by pleural fluid cholesterol. IP Indian Journal of Neurosciences. 2023 Jan 19;7(1):33-8.
15. Luke DA. Global Trends, Regional Disparities, and the Role of Case Detection in Tuberculosis Mortality. Medical Journal of Public Health. 2026 Apr 7;1(1):01-9.
16. Tung A, Bilaceroglu S, Porcel JM, Creaney J, Lee G. Biomarkers in pleural diseases. US Respiratory Disease. 2011;7:26-31.
17. Subedi AR, Shrestha TM, Shakya YL, Budha B. Comparative Evaluation of Pleural Fluid Cholesterol and Total Protein Versus Light's Criteria in Differentiation of Exudates and Transudates: A Cross-Sectional Analysis at Tribhuvan University Teaching Hospital. Clin Respir J. 2025 Sep;19(9):e70121.

ISSN (O): 2687-5365; ISSN (P): 2753-6556