e-ISSN: 0976-822X, p-ISSN:2961-6042

Available online on http://www.ijcpr.com/

International Journal of Current Pharmaceutical Review and Research 2026; 18(2); 2193-2203

Original Research Article

Etiological Spectrum and Biochemical Characteristics of Pleural Effusion in A Tertiary Care ICU

Ritwik Chakraborty[1], Sourabh Kumar[2], Mohammad Shoaib[3], Gyanendra Agrawal[4]

[1]Consultant Critical Care Medicine, Max Superspeciality Hospital Vaishali Ghaziabad, India
[2]Assistant Professor, Department of Critical Care Medicine, Himalayan Institute of Medical Sciences (HIMS), Swami Rama Himalayan University, Jollygrant, Dehradun, India
[3]Consultant Critical Care Medicine, Livasa hospital khanna Punjab, India
[4]Senior Director, Department of Critical Care, Max Super Speciality Hospital, Noida, India

Received: 24-12-2025 / Revised: 23-01-2026 / Accepted: 25-02-2026
Corresponding Author: Ritwik Chakraborty
Conflict of interest: Nil

Abstract:

Background: Among critically ill patients hospitalized to intensive care units (ICUs), pleural effusion is a common clinical issue that frequently reflects a variety of underlying systemic or pulmonary illnesses. Pleural effusions have been linked to respiratory compromise, longer mechanical ventilation, higher morbidity, and delayed recovery in the intensive care unit. For a timely diagnosis and focused treatment, determining the etiological spectrum and examining the biochemical properties of pleural fluid are crucial. The purpose of this study is to investigate the biochemical profile of pleural fluid using conventional diagnostic measures and to determine the prevalent causes of pleural effusion in patients admitted to a tertiary care intensive care unit.

Methods: Adult ICU patients with pleural effusions identified by clinical examination and imaging were included in a prospective observational research. Pleural fluid was examined for appearance, protein, lactate dehydrogenase (LDH), glucose, pH, adenosine deaminase (ADA), cell count, and microbiological/cytological investigation where necessary. Diagnostic thoracentesis was carried out under aseptic precautions. Light's criteria were used to categorize effusions as either transudative or exudative.

Results: Parapneumonic effusion, congestive heart failure, sepsis-related effusion, tuberculosis, cancer, renal failure, and hypoalbuminemia were among the expected etiological range. Transudative effusions were more frequently linked to cardiac and renal causes, whereas exudative effusions were predicted to prevail, especially among patients with infection and inflammatory illnesses. While lymphocytic predominance and elevated ADA supported tubercular origin, elevated protein and LDH levels, low glucose, neutrophilic predominance, and acidic pH were more common in infected effusions.

Conclusion: The study emphasizes the importance of biochemical pleural fluid analysis in identifying the cause and directing treatment choices, as well as the variability of pleural effusions in critically ill patients. In ICU settings, early detection and methodical assessment of pleural effusion may enhance patient outcomes and lessen complications.

Keywords: Pleural Fluid, Cardiogenic Pleural Effusion, Diagnostic Criteria, Non-Cardiogenic Aetiologies.

DOI: 10.25258/ijcpr.18.2.362

This is an Open Access article that uses a funding model which does not charge readers or their institutions for access and distributed under the terms of the Creative Commons Attribution License (http://creativecommons.org/licenses/by/4.0) and the Budapest Open Access Initiative (http://www.budapestopenaccessinitiative.org/read), which permit unrestricted use, distribution, and reproduction in any medium, provided original work is properly credited.

Introduction

Pleural effusion is a frequently encountered complication among critically ill patients admitted to intensive care units (ICUs), arising from a wide spectrum of cardiac, pulmonary, infectious, inflammatory, and systemic disorders. In critically ill individuals, pleural fluid accumulation not only reflects the severity of the underlying disease but also contributes to impaired respiratory mechanics, reduced pulmonary compliance, compromised gas exchange, prolonged mechanical ventilation, and increased ICU stay. The heterogeneous etiology of pleural effusion in ICU patients often makes clinical differentiation challenging, emphasizing the need for prompt diagnostic evaluation. Accurate identification of the underlying cause through biochemical analysis of pleural fluid is essential for timely therapeutic decision-making and improved clinical outcomes. [1].

Due to a number of concomitant conditions, including fluid overload, hypoalbuminemia, systemic inflammation, mechanical ventilation, congestive heart failure, and nosocomial infections, pleural effusion is more common in ICU patients than in regular ward populations.

In individuals with low cardiopulmonary reserve, even little pleural effusions can have a substantial impact on lung compliance and oxygenation. Thus, in the context of critical care, prompt identification and suitable treatment are crucial from a therapeutic standpoint [2].

It is crucial to identify the underlying cause of pleural effusion because different etiologies require different therapeutic approaches. The mainstay of assessment is still diagnostic thoracentesis with pleural fluid analysis. Together with cytological and microbiological analysis, biochemical assays like protein content, lactate dehydrogenase (LDH), glucose, pH, and adenosine deaminase (ADA) offer important hints about the type of effusion. Light's criteria are frequently used to help restrict the differential diagnosis and differentiate between transudative and exudative effusions [3].

Because sepsis, multi-organ dysfunction, cancer, and advanced chronic diseases are more common in tertiary care ICUs than in community settings, the etiological profile of pleural effusion may be different. The range of reasons may also be influenced by regional differences, such as the frequency of tuberculosis and illnesses linked to healthcare. The purpose of this study was to examine the biochemical properties of pleural fluid and evaluate the etiological spectrum of pleural effusion in patients hospitalized to a tertiary care intensive care unit. In critically ill populations, an understanding of these patterns may help with early diagnosis, direct treatment approaches, and enhance overall patient outcomes [4].

Methodology

Study Location: This study was carried out in the Medical-Intensive Care Unit and Medical wards under Department of Critical Care Medicine of Jaypee hospital, Noida. This is a 525 bedded multi-speciality hospital and 56 bedded ICU treating multivariate medical and surgical patients.

Type of Study: Prospective and observational study.

Study Population and Study Duration: All adult patients above 18 years of age with radiologically determined pleural effusion that could be drained by thoracocentesis admitted in the hospital between March 2021 and December 2022 were prospectively included in our study after obtaining written informed consent from them. Clinical presentation of the patients was recorded, pleural fluid, serum samples were collected & radiological investigations as noted below were performed. Pleural fluid was collected by ultrasound guided diagnostic thoracocentesis.

Inclusion Criteria

- All adult patients above 18 years of age with radiologically determined pleural effusion that could be drained by thoracocentesis.

Exclusion Criteria

- Renal failure
- Coagulopathy
- Thoracic deformity interfering with thoracocentesis
- Effusion with more than one possible cause
- Hemothorax, chylothorax, urinothorax

Sample Size: The study of Cincin A et al[60] observed that sensitivity and specificity of NT-proBNP for discriminating transudates caused by heart failure from exudates was 70.8% and 97.6% respectively. Taking these values as reference, the minimum required sample size with desired precision of 15%, 90% power of study and 5% level of significance is 80 patients.

Statistical Analysis: Categorical variables were represented as counts and percentages, whilst quantitative data were displayed as mean ± standard deviation or median with interquartile range. The Kolmogorov-Smirnov test was employed to evaluate normality. Chi-square or Fisher's exact test evaluates categorical variables. The Spearman correlation evaluated the associations of NT-proBNP. Kappa statistics assessed concordance. The Mann-Whitney test is utilised for the comparison of non-parametric data. The ROC curve established diagnostic thresholds based on sensitivity and specificity. Data were analysed utilising SPSS version 25.0, with a p-value of less than 0.05 being statistically significant.

Results

A total of 93 adult ICU patients with radiologically confirmed pleural effusion were enrolled during the study period. Most participants belonged to the 51–60-year age group (84.95%), with a mean age of 56.62 ± 5 years, indicating that pleural effusion was predominantly observed among middle-aged and elderly critically ill patients. Females constituted 53.76% of the study population, while males accounted for 46.24%.

Table 1: Distribution of age (years) of study subjects

Age(years)	Frequency	Percentage
51-60	79	84.95%
61-70	14	15.05%
Mean ± SD	56.62 ± 5	
Median(25th-75th percentile)	56(53-58)	
Range	51-70	

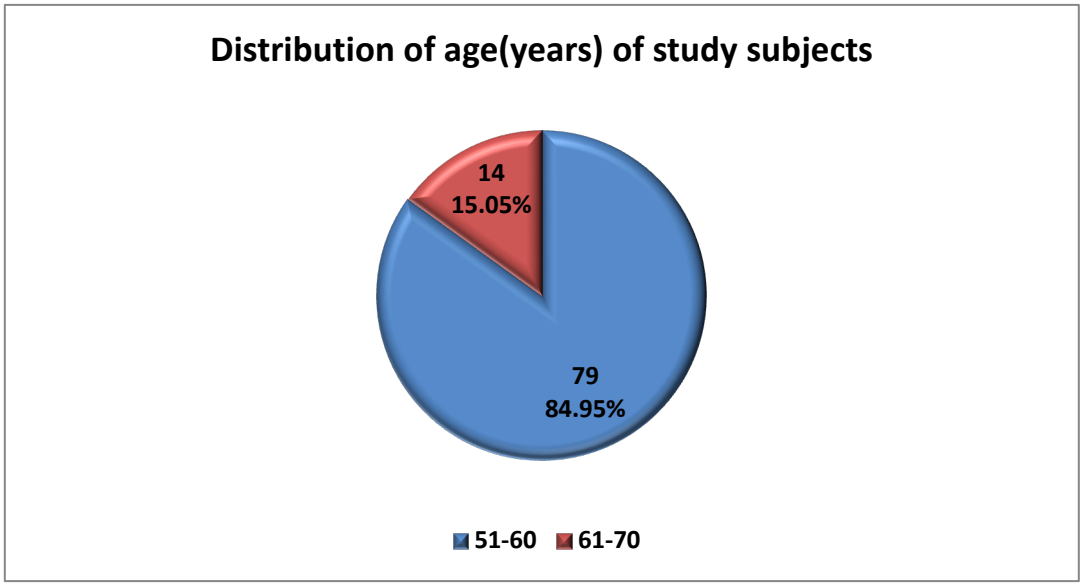


Figure 1: Distribution of age (years) of study subjects

Table 2: Distribution of gender of study subjects

Gender	Frequency	Percentage
Female	50	53.76%
Male	43	46.24%
Total	93	100.00%

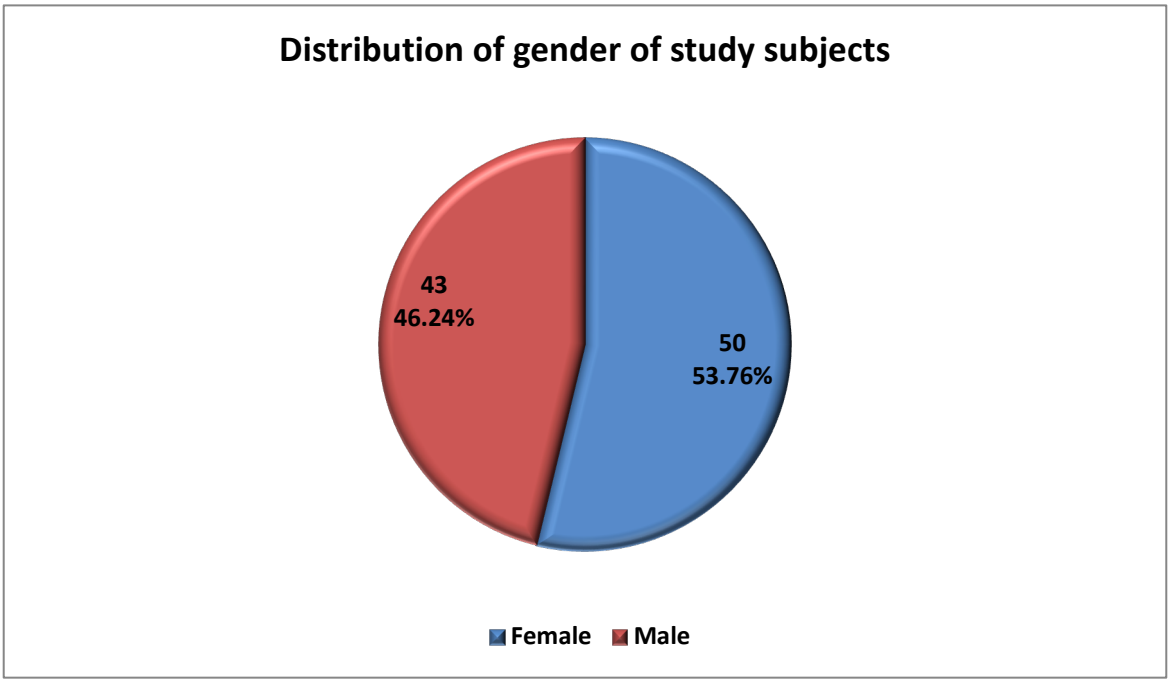


Figure 2: Distribution of gender of study subjects

Table 3: Descriptive statistics of body weight (kg) of study subjects

Variable	Mean ± SD	Median(25th-75th percentile)	Range
Body weight (kg)	65.24 ± 3.26	65(63-68)	54-77

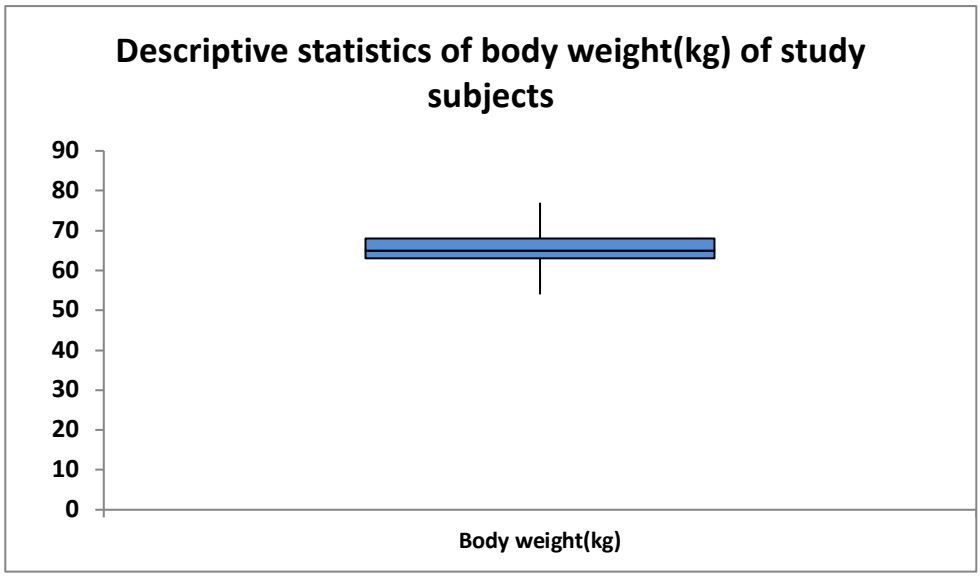


Figure 3: Descriptive statistics of body weight (kg) of study subjects

Table 4: Distribution of nature of fluid of study subjects

Nature of fluid	Frequency	Percentage
Exudative	47	50.54%
Transudative	46	49.46%
Total	93	100.00%

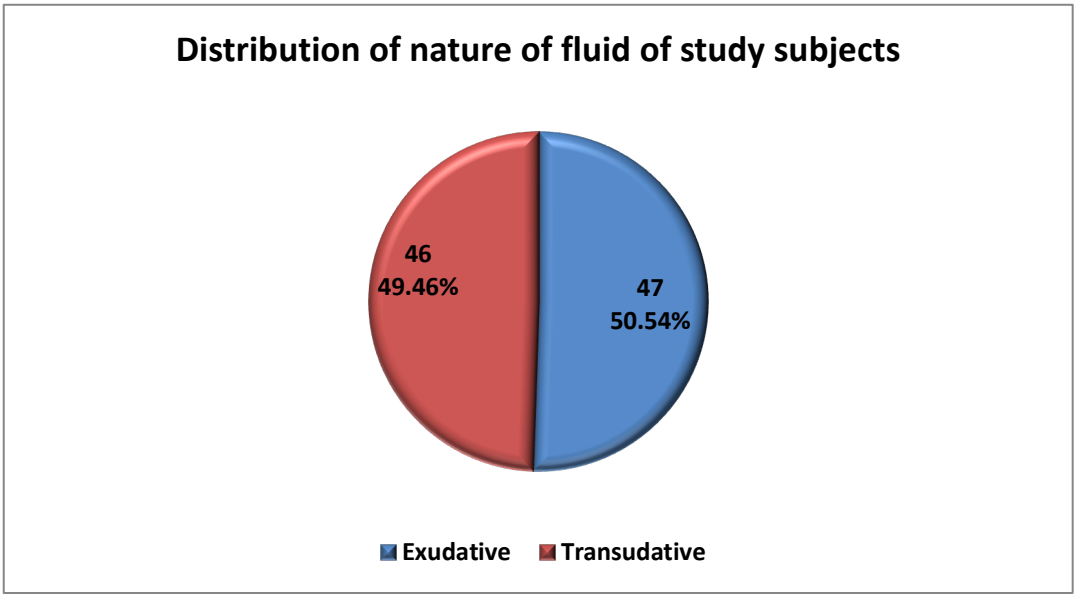


Figure 4: Distribution of nature of fluid of study subjects

Table 5: Distribution of diagnosis of study subjects

Diagnosis	Frequency	Percentage
Non cardiogenic pleural effusion	61	65.59%
Cardiogenic pleural effusion	32	34.41%
Total	93	100.00%

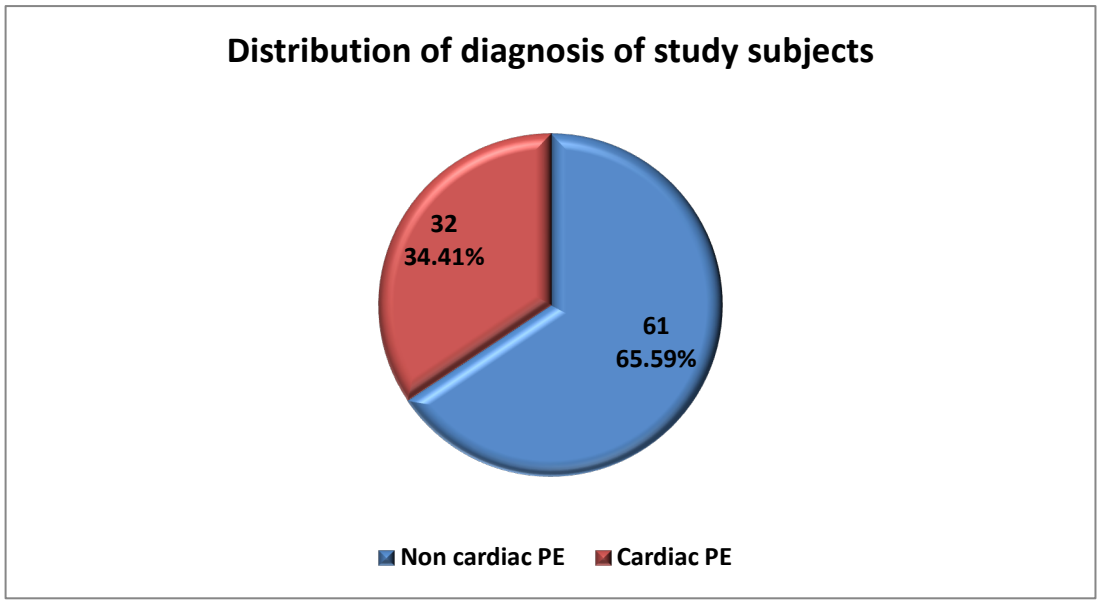


Figure 5: Distribution of diagnosis of study subjects

Table 6: Distribution of provisional diagnosis of study subjects

Provisional diagnosis	Frequency	Percentage
Bacterial pneumonia	18	19.35%
Cardiac failure	32	34.41%
Chronic kidney disease	10	10.75%
Chronic liver disease	12	12.90%
Malignancy	8	8.60%
Tuberculosis	13	13.98%
Total	93	100.00%

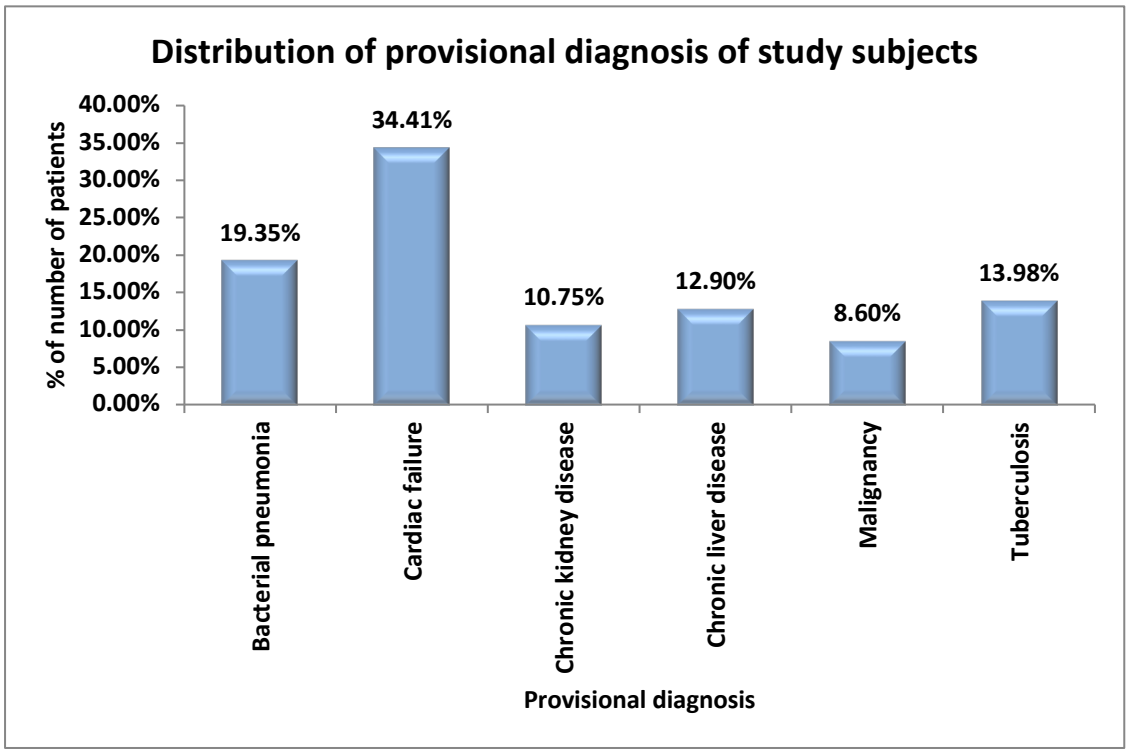


Figure 6: Distribution of provisional diagnosis of study subjects

Analysis of pleural fluid revealed a nearly equal distribution of exudative (50.54%) and transudative (49.46%) effusions. However, etiological classification demonstrated that non-cardiogenic

pleural effusions predominated (65.59%), whereas cardiogenic pleural effusions accounted for 34.41% of cases. Among individual etiologies, cardiac failure was the commonest diagnosis (34.41%), followed by bacterial pneumonia (19.35%), tuberculosis (13.98%), chronic liver disease (12.90%), chronic kidney disease (10.75%), and malignancy (8.60%).

Table 7: Comparison of pleural fluid NT-Pro BNP (pg/mL) between cardiogenic pleural effusion and Non cardiogenic Pleural effusion

Pleural fluid NT-Pro BNP (pg/mL)	Non-Cardiogenic pleural effusion (n=61)	Cardiogenic pleural effusion (n=32)	Total	P value
Mean ± SD	490.39 ± 492	11555.5 ± 2103.79	4297.74 ± 5438.97	<.0001‡
Median(25th-75th percentile)	152 (128-1100)	11054 (9743-13107)	1100 (145-9767)	
Range	98-1459	9140-15908	98-15908	

‡ **Mann Whitney test**

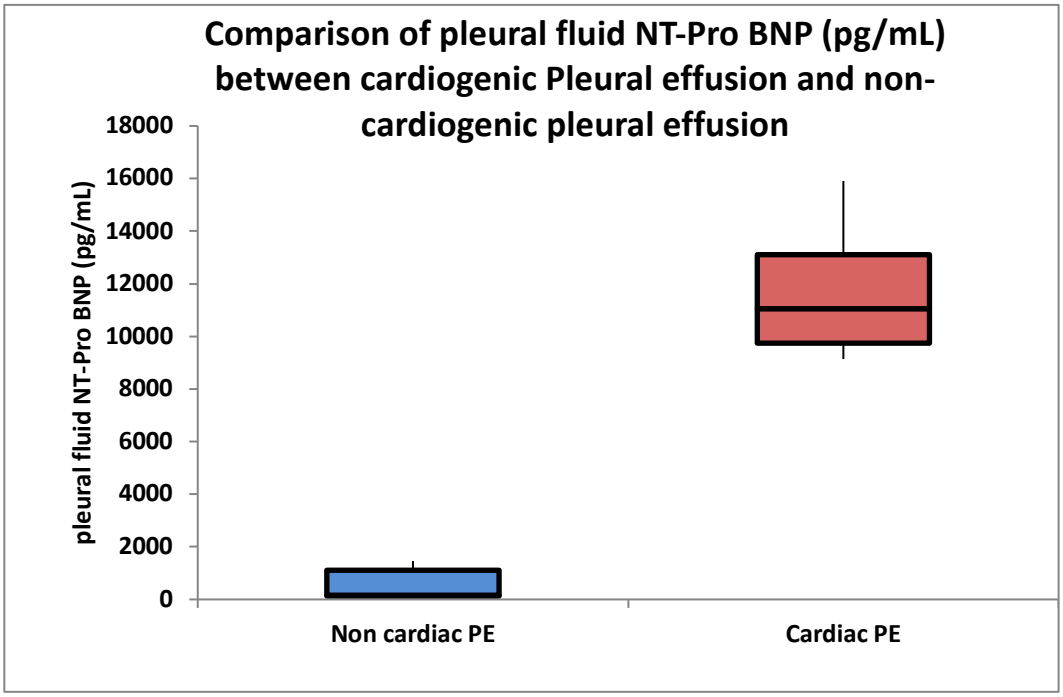


Figure 7: Comparison of pleural fluid NT-Pro BNP (pg/mL) between cardiogenic pleural effusion (PE) and non-cardiogenic pleural effusion (PE) (non-parametric variable, Box-whisker plot)

Table 8: Comparison of serum NT-Pro BNP (pg/mL) between cardiogenic pleural effusion and non-cardiogenic Pleural effusion

Serum NT-Pro BNP (pg/mL)	Non-Cardiogenic Pleural Effusion(n=61)	Cardiaogenic Pleural Effusion (n=32)	Total	P value
Mean ± SD	473.49 ± 469.62	11267.34 ± 2009.53	4187.51 ± 5299.52	<.0001‡
Median(25th-75th percentile)	149 (125-1020)	10778 (9523.75-13008.5)	1020 (142-9543)	
Range	99-1239	8898-15098	99-15098	

‡ **Mann Whitney test**

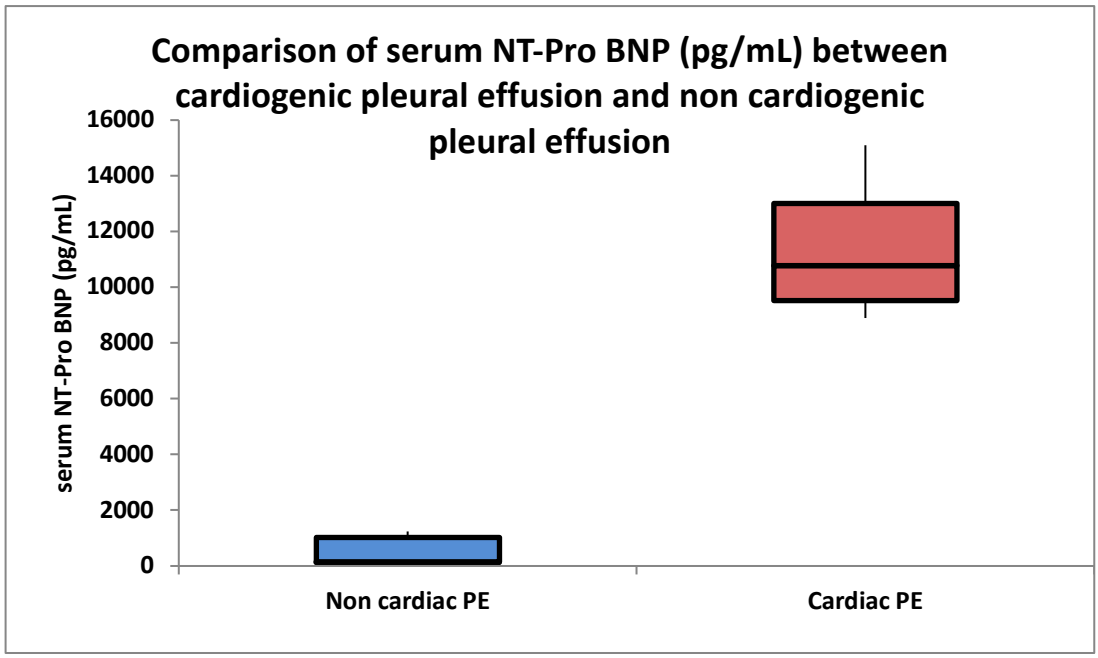


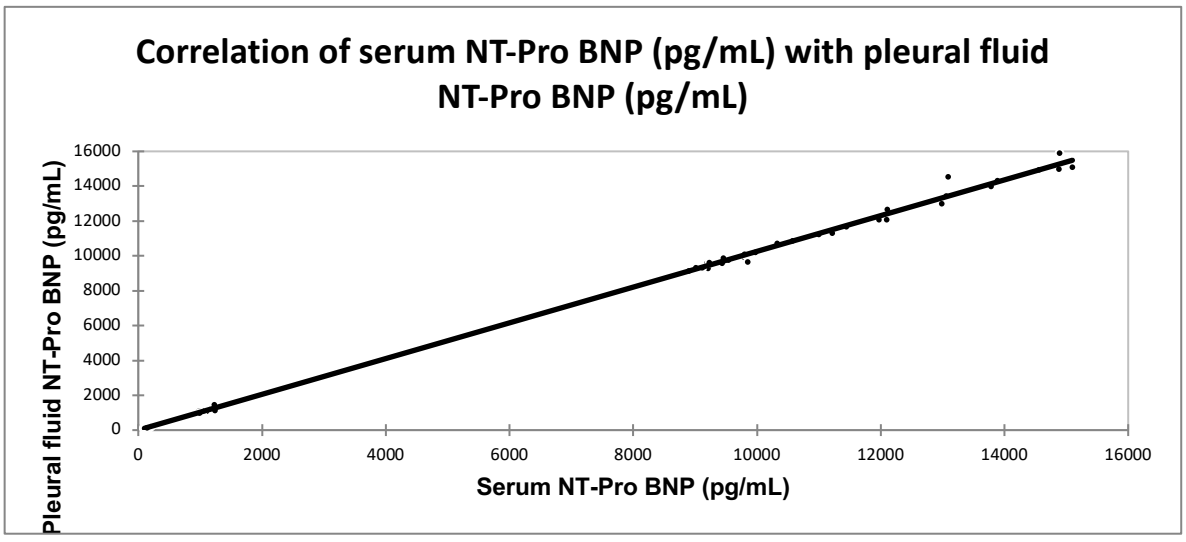
Figure 8: Comparison of serum NT-Pro BNP (pg/mL) between cardiogenic pleural effusion (PE) and non-cardiogenic pleural effusion (PE) (non-parametric variable, Box-whisker plot)

Pleural fluid and serum NT-proBNP concentrations were markedly higher in patients with cardiogenic pleural effusion than in those with non-cardiogenic causes ($p<0.0001$). Furthermore, serum and pleural fluid NT-proBNP levels demonstrated an excellent positive correlation ($r=0.977$, $p<0.0001$). ROC curve analysis showed outstanding diagnostic performance, with pleural fluid NT-proBNP >1459 pg/mL achieving 100% sensitivity, specificity, PPV, NPV, and overall diagnostic accuracy. Importantly, seven patients initially categorized as exudative according to Light's criteria were correctly reclassified as cardiogenic pleural effusions using pleural fluid NT-proBNP estimation.

Table 9: Correlation of serum NT-Pro BNP (pg/mL) with pleural fluid NT-Pro BNP (pg/mL)

Variables	Pleural fluid NT-Pro BNP (pg/mL)
Serum NT-Pro BNP (pg/mL)	
Correlation coefficient	0.977
P value	<0.0001

Spearman rank correlation coefficient



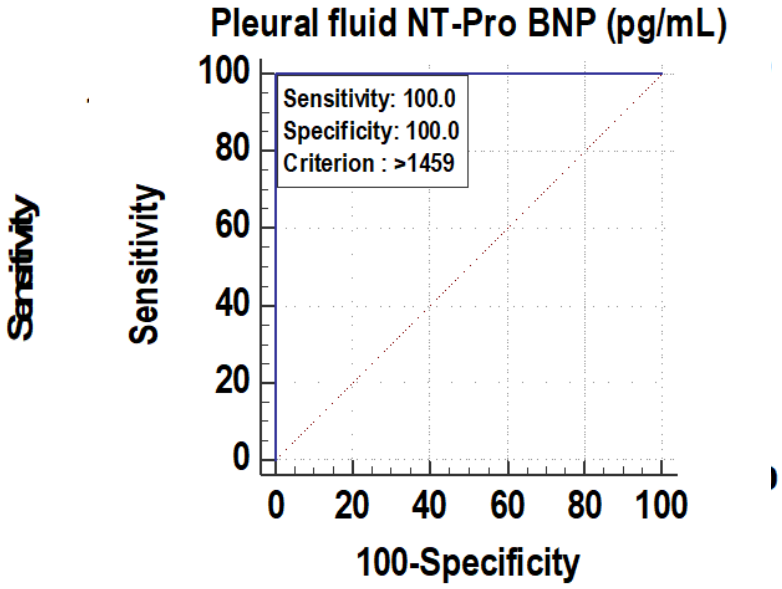


Figure 9: Correlation of serum NT-Pro BNP (pg/mL) with pleural fluid NT-Pro BNP (pg/mL)

Table 10: Receiver operating characteristic curve of serum NT-Pro BNP (pg/mL) and pleural fluid NT-Pro BNP (pg/mL) for predicting cardiogenic pleural effusion

Variables	Serum NT-Pro BNP (pg/mL)	Pleural fluid NT-Pro BNP (pg/mL)
Area under the ROC curve (AUC)	1	1
Standard Error	0	0
95% Confidence interval	0.961 to 1.000	0.961 to 1.000
P value	<0.0001	<0.0001
Cut off	>1239	>1459
Sensitivity(95% CI)	100%(89.1 - 100.0%)	100%(89.1 - 100.0%)
Specificity(95% CI)	100%(94.1 - 100.0%)	100%(94.1 - 100.0%)
PPV(95% CI)	100%(89.1 - 100.0%)	100%(89.1 - 100.0%)
NPV(95% CI)	100%(94.1 - 100.0%)	100%(94.1 - 100.0%)
Diagnostic accuracy	100.00%	100.00%

Figure 10(a):- Receiver operating characteristic curve of Serum NT-Pro BNP (pg/mL) for predicting cardiogenic pleural effusion.

Figure 10(b): Receiver operating characteristic curve of pleural fluid NT-Pro BNP (pg/mL) for predicting cardiogenic pleural effusion

Table 11: Distribution of misclassified cardiogenic pleural effusions correctly classified by pleural fluid NT-Pro BNP

Variables	Frequency	Percentage
Misclassified cases	7	7.53%
Total	93	100.00%

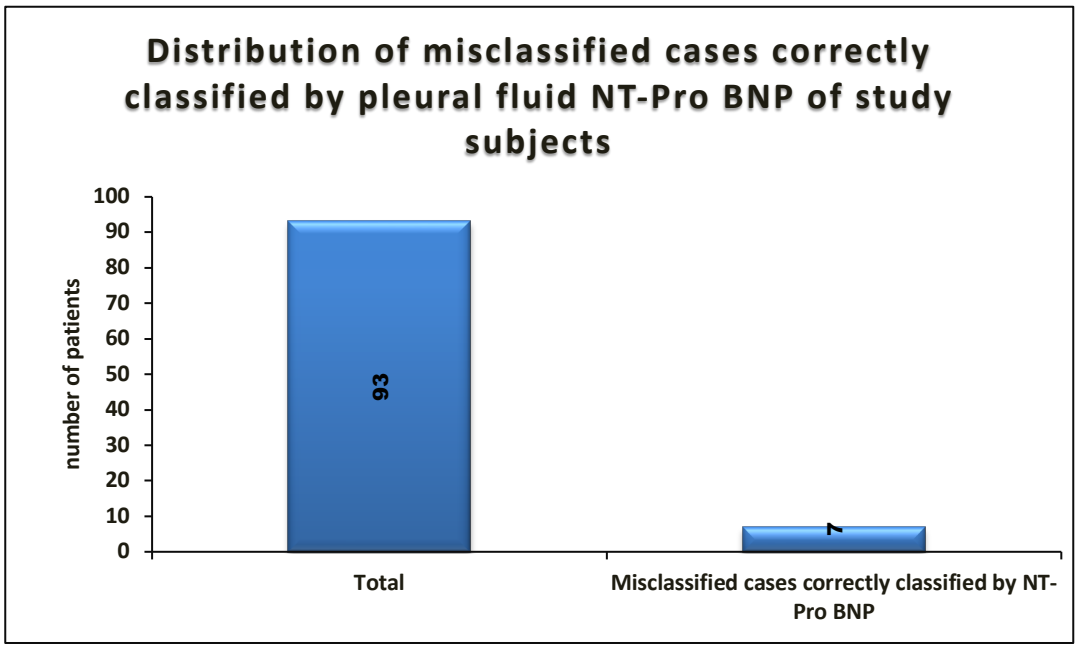


Figure 11: Distribution of misclassified cases correctly classified by pleural fluid NT-Pro BNP of study subjects

Table 12: Descriptive statistics of pleural fluid NT-Pro BNP (pg/mL) in the misclassified pleural effusion of study subjects.

Variable	Mean ± SD	Median(25th-75th percentile)	Range
Pleural fluid NT-Pro BNP (pg/mL) in the misclassified pleural effusion	11279.43 ± 2085.6	11302 (9618-12094.5)	9140-15089

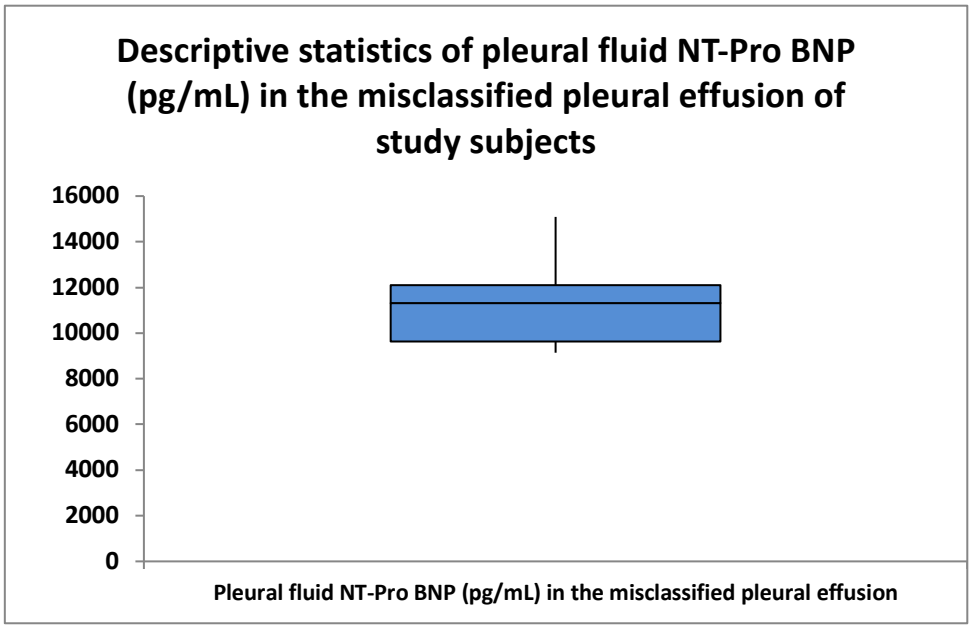


Figure 12: Descriptive statistics of pleural fluid NT-Pro BNP (pg/mL) in the misclassified pleural effusion of study subjects.

Discussion

The present study demonstrates that pleural effusion in critically ill patients represents a heterogeneous clinical entity with both cardiac and non-cardiac etiologies contributing substantially to disease burden. Although non-cardiogenic pleural effusions were more prevalent overall, congestive cardiac failure remained the single most frequent individual

diagnosis, highlighting the importance of considering cardiac dysfunction in ICU patients presenting with pleural fluid accumulation.

A nearly equal distribution of exudative and transudative pleural effusions was observed. Infectious conditions, particularly bacterial pneumonia and tuberculosis, accounted for most exudative effusions, whereas cardiac failure was the predominant cause of transudative effusions. These findings are consistent with the complex pathophysiological mechanisms encountered in critically ill patients, where systemic inflammation, infection, organ dysfunction, and fluid imbalance often coexist [5].

One of the major findings of this study was the remarkable diagnostic performance of NT-proBNP. Both pleural fluid and serum NT-proBNP levels were significantly elevated in cardiogenic pleural effusions, with minimal overlap between cardiogenic and non-cardiogenic groups. The very strong positive correlation between serum and pleural fluid NT-proBNP further confirms that pleural fluid estimation accurately reflects underlying cardiac dysfunction and may serve as a practical alternative when serum measurements are unavailable [6].

Receiver operating characteristic analysis demonstrated excellent diagnostic accuracy for pleural fluid NT-proBNP, with a cutoff value exceeding 1459 pg/mL yielding 100% sensitivity and specificity for identifying cardiogenic pleural effusions in this cohort. These findings reinforce the utility of NT-proBNP as an adjunctive biomarker alongside conventional biochemical analysis [7].

An important clinical observation was that seven patients initially classified as exudative according to Light's criteria were subsequently identified as cardiogenic pleural effusions based on elevated pleural fluid NT-proBNP levels. Misclassification following diuretic therapy is a well-recognized limitation of Light's criteria, and the present findings demonstrate how NT-proBNP measurement can substantially improve diagnostic accuracy and reduce inappropriate investigations or treatment delays [8].

Overall, the findings suggest that incorporation of pleural fluid NT-proBNP into routine diagnostic evaluation may significantly improve etiological classification of pleural effusions in critically ill patients, thereby facilitating earlier targeted management and optimizing patient outcomes. Nevertheless, larger multicenter studies are warranted to validate these observations across diverse ICU populations [9].

Overall, the current study shows that pleural fluid NT-Pro BNP can greatly increase diagnostic accuracy in ICU patients and is a very useful biomarker for differentiating cardiogenic pleural effusions from non-cardiogenic sources.

Conclusion

The research indicated that the median pleural fluid NT-proBNP levels were markedly elevated in individuals with cardiogenic pleural effusion in contrast to those with non-cardiogenic origins, underscoring its substantial diagnostic significance. At a threshold of >1459 pg/mL, pleural fluid NT-proBNP demonstrated exceptional diagnostic accuracy, achieving 100% sensitivity and 100% specificity in detecting cardiogenic pleural effusion. Moreover, it demonstrated significant efficacy in accurately reclassifying pleural effusions that were initially misidentified as exudative according to Light's criteria, especially in patients on diuretic treatment. This underscores its therapeutic efficacy in preventing diagnostic inaccuracies and superfluous procedures. A robust positive association was discovered between blood NT-proBNP and pleural fluid NT-proBNP levels, signifying that both metrics are intimately connected and can accurately indicate cardiac dysfunction. In summary, pleural fluid NT-proBNP is a reliable and precise biomarker for distinguishing cardiogenic from non-cardiogenic pleural effusions.

References

1. Janda S, Swiston J. Diagnostic accuracy of pleural fluid NT-pro-BNP for pleural effusions of cardiac origin : a systematic review and meta-analysis. BMC Pulm Med [Internet]. 2010;10(1):58.
2. Han CH, Jung Eun Choi and JHC. Clinical Utility of Pleural Fluid NT-pro Brain Natriuretic Peptide (NT-proBNP) in Patients with Pleural Effusions. Inter Med. 2008;47:1669–74.
3. Wijayaratne T, Yousuf A, Panchal R. Cardiac related pleural effusions : a narrative review. J Thorac Dis. 2024;16(2):1674–86.
4. Hezzell MJ, Rush JE, Humm K, Rozanski EA, Sargent J, Connolly DJ, et al. Differentiation of Cardiac from Noncardiac Pleural Effusions in Cats using Second-Generation Quantitative and Point-of-Care NT-proBNP Measurements. J Vet Intern Med. 2016;30:536–42.
5. Abdalla ME, Abd H, Azeem E, Mousa A. Diagnostic value of NT – PRO BNP in cardiogenic and non-cardiogenic pleural effusions. Egypt J Chest Dis Tuberc [Internet]. 2013;61:109–14. Available from: http://dx.doi.org/10.1016/j.ejcdt.2012.10.022
6. Al JMPET, Porcel JM. Development and validation of a diagnostic prediction model for heart failure-related pleural effusions : the BANCA score. ERJ OPEN Res [Internet]. 2025;11(01030):1–9.

7. Medicine CC, Hospital J. Evaluation of efficacy of pleural fluid nut-brown in differentiating pleural effusion due to cardiac failure from pleural effusion of non-cardiac origin Ritwik Chakraborty Gyanendra Agrawal Smita Sharma. Int J Sci Res. 2024;13(5):35–7.
8. Yeh J, Huang C, Liu C, Ruan S, Tsai Y, Chien Y, et al. Cautious Application of Pleural N-Terminal Pro-B-Type Natriuretic Peptide in Diagnosis of Congestive Heart Failure Pleural Effusions among Critically Ill Patients. PLoS One. 2014;9(12):1–11.
9. Babapour B, Mirzaaghazadeh M, Shahbazzadegan B, Mohsenifar H, Mohammadzadeh A, Zamani B. Evaluation of diagnostic value of n-terminal pro brain natriuretic peptide in pleural fluid with cardiac origin. Int J Community Med Public Heal. 2018;5(3):912–6.