ORIGINAL ARTICLE

Prognosticating pleural infection based on RAPID score in a tertiary-care hospital

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ABSTRACT

Background: Pleural infection remains a significant cause of morbidity and mortality worldwide. The study aims to determine the mortality risk in patients with pleural infection using the renal function, Age, Purulence of pleural fluid, infection source, and dietary status (RAPID) score in a tertiary-care hospital in Karachi.

Material and Methods: A cross-sectional study was conducted at the Chest Unit-1, Ojha Institute of Chest Diseases, Dow University of Health Sciences, from 11th February 2025 to 10th August 2025. A total of 171 patients aged 18–80 years with confirmed pleural infection were enrolled through non-probability consecutive sampling. Demographic, clinical, laboratory, and pleural fluid data were collected, and the RAPID score was calculated for each patient. Data were analyzed using SPSS V.25, Quantitative variables were reported as mean ± SD or median (IQR) based on distribution, and categorical variables as frequencies and percentages. Associations were tested using chi-square or Fisher's exact test.

Results: Of the 171 patients, 75 (43.9 %) were male, and the mean age was 55.1 ± 13.05 years. RAPID score distribution was low risk in 78 (45.6%), moderate in 58 (33.9%), and high in 35 (20.5%). Mortality rates were 3.5% in the low-risk group, 15.5% in the moderate group, and 46.4% in the high-risk group ($p < 0.001$). High RAPID scores were also associated with longer hospital stay median 12 (IQR 9–15) vs. 8 (IQR 6–11) days, $p = 0.002$.

Conclusion: The RAPID score reliably stratifies pleural infection patients into mortality risk categories, enabling early identification of high-risk cases and timely intervention.

Keywords: Mortality, Pleural infection, Prognosis, RAPID score, Tertiary care.

BACKGROUND

Pleural infection in adults is a common and increasingly recognized clinical problem in thoracic medicine, associated with significant morbidity and mortality. It remains a life-threatening condition, particularly if diagnosis and management are delayed.[1,2] Epidemiological data from North America, Western Europe, and East Asia indicate that the incidence of pleural infection during the second decade of the 21st century ranges from 6.7 to 9.9 cases per 100,000 population, nearly doubling compared to the first decade.[3-5] Mortality associated with pleural infection remains substantial, with reported overall rates of 10% at three months and 19% at twelve months.[6]

The clinical course of pleural infection is typically progressive and can be categorized into three stages: the simple exudative stage, the fibrin purulent stage, and the organizing stage.[7] Early recognition and timely management of each stage are crucial to prevent complications, prolonged hospitalization, and mortality. Accurate identification of the causative pathogens in pleural infection is essential, as treatment decisions and prognosis largely depend on the microbiological profile. However, the spectrum of pathogens varies significantly across geographic regions and according to the resources available in healthcare settings.[8,9] Delayed etiological diagnosis has been associated with increased morbidity and poor outcomes, highlighting the importance of prompt clinical, radiological, and laboratory assessment.[10]

Over the years, several clinical scoring systems have been developed to improve the prediction of disease severity and mortality in pleural infection. Among these, the RAPID score, which incorporates Renal function (urea), Age, fluid Purulence, Infection source, and Dietary status (serum albumin), has emerged as a validated and reliable tool for risk stratification.[11] Patients are categorized into low risk (0–2), medium risk (3–4), and high risk (5–7) groups, with mortality risk rising proportionally with increasing scores. Previous studies have demonstrated the utility of the RAPID score in predicting both short- and long-term mortality.[12,13] These findings highlight the value of the RAPID score as a simple bedside tool, and justify its use

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in local populations where epidemiological data are scarce.

The RAPID score is a validated clinical prediction model designed to stratify risk in patients with pleural infection. The acronym represents renal function, Age, Purulence of pleural fluid, Infection source, and Dietary status (serum albumin). Each component contributes to a total score ranging from 0 to 7, with higher scores indicating greater risk of mortality and poor clinical outcomes. RAPID score has demonstrated strong prognostic value in international cohorts, assisting clinicians in early identification of high-risk patients and guiding decisions regarding aggressive drainage, antibiotic escalation, or closer monitoring. Despite its growing utility, local data from tertiary-care settings remain limited, warranting further evaluation in our population.

The rationale for the present study is to determine mortality risk in patients presenting with pleural infection at a tertiary care hospital in Karachi using the RAPID scoring system. Early diagnosis and risk stratification are essential for pulmonologists to tailor management strategies, prioritize high-risk patients, and optimize clinical outcomes.

MATERIAL AND METHODS

This cross-sectional study was conducted over a six-month period at the Chest Unit-1, Pulmonology Department, Ojha Institute of Chest Diseases, Dow University of Health Sciences, Karachi. Ethical approval was obtained from the Institutional Review Board (Approval No. IRB-3809/DUHS/Approval/2025/43). All procedures followed institutional guidelines and the Declaration of Helsinki.

A total of 171 patients aged 18–80 years with confirmed pleural infection were enrolled using non-probability consecutive sampling. Patients with post-operative pleural infections, chronic renal, cardiac, or respiratory failure, or those unwilling to participate were excluded.

Sample size was calculated using OpenEpi Version 3.01 software, assuming a 20% prevalence of high-risk RAPID score group, 95% confidence interval, and 6% margin of error, based on previously published data. This reference population proportion was used in the calculation published literature on RAPID score distribution in pleural infection patients.[14]

Demographic data, clinical features (chest pain, dyspnea, fever, cough), and laboratory parameters (white blood cell count, C-reactive protein, serum albumin, blood urea nitrogen, pleural fluid pH) were recorded. Imaging with chest X-ray and CT scan (when indicated) confirmed pleural effusion. Thoracentesis was conducted for pleural fluid analysis, including pH, cytology, and culture.

The RAPID score was calculated for each patient and categorized into low (0–2), moderate (3–4), and high (5–7) risk groups.

Data were analyzed using Statistical Package for the Social Sciences (SPSS) version 25. Quantitative variables were expressed as mean ± SD for normally distributed variables (age, duration of symptoms, fever, CRP, serum albumin, BUN, pleural pH, RAPID score) and as median (IQR) for non-normally distributed variables (monthly income, WBC). Normality was assessed using the Shapiro–Wilk test. Qualitative variables (gender, residence, chest pain, dyspnea, cough, fever, infection source, microorganism type, RAPID category) were reported as frequencies and percentages.

Associations between RAPID score categories and outcomes were assessed using chi-square or Fisher's exact test. Comparisons of continuous variables between groups were performed using independent-samples t-test. A p-value ≤ 0.05 was considered statistically significant.

RESULTS

A total of 171 patients with pleural infection were included in the study. Out of 171 participants, 75 (43.9%) were male and 96 (56.1%) were female. The mean age was 55.1 ± 13.0 years. Slightly more patients resided in urban areas (88; 51.5%) compared to rural areas (83; 48.5%). Table-I shows the measures of central tendency and dispersion for quantitative variables.

Age, symptom duration, fever, CRP, serum albumin, BUN, pleural pH, and RAPID score followed normal distribution and are presented as mean ± SD. Monthly income and WBC count were non-normally distributed and are presented as median (IQR).

The majority of patients had cough (154; 90.1%) and fever (160; 93.6%). S. pneumoniae was the most common microorganism isolated (94; 55.0%) (Table-II).

A significant association was observed between age group and mortality risk ($p = 0.014$), with patients aged >70 years having the highest proportion in the high-risk RAPID category. No statistically significant association was found between RAPID score categories and gender,

residence, monthly income, duration of symptoms, or type of microorganism (Table-III).

Table-I. Descriptive statistics of quantitative variables (n=171)

Variable	Mean ± SD / Median (IQR)
Age (years)	55.1 ± 13.0
Monthly income (PKR)	27,500 (20,000–35,000)
Fever (°F)	101.7 ± 1.5
WBC (cells/µL)	13,400 (11,200–15,300)
CRP (mg/dL)	5.9 ± 2.4
Serum albumin (g/dL)	2.5 ± 0.6
BUN (mg/dL)	17.8 ± 4.3
Pleural pH	7.21 ± 0.08
RAPID score	3.2 ± 1.3

Table-II: Frequency distribution of clinical variables (n=171).

Variable	Category	n (%)
Gender	Male	75 (43.9)
	Female	96 (56.1)
Residence	Rural	83 (48.5)
	Urban	88 (51.5)
Chest pain	Present	135 (78.9)
	Absent	36 (21.1)
Dyspnea	Present	123 (71.9)
	Absent	48 (28.1)
Cough	Present	154 (90.1)
	Absent	17 (9.9)
Fever	Present	160 (93.6)
	Absent	11 (6.4)
Source of infection	Community-acquired	129 (75.4)
	Hospital-acquired	42 (24.6)
RAPID mortality risk	Low	78 (45.6)
	Moderate	58 (33.9)
	High	35 (20.5)
Identified microorganism	*S. pneumoniae*	94 (55.0)
	S. aureus	38 (22.2)
	Others	39 (22.8)

Table-III: Associations between stratification variables and mortality risk categories (RAPID score) (n=171).

Variable	Category	Low n (%)	Moderate n (%)	High n (%)	p-value
Gender	Male	34 (45.3)	25 (43.1)	16 (45.7)	0.648
	Female	44 (54.7)	33 (56.9)	19 (54.3)	
Age group	<50 years	33 (42.3)	16 (27.6)	6 (17.1)	0.014*
	50–70 years	29 (37.2)	28 (48.3)	13 (37.1)	
	>70 years	16 (20.5)	14 (24.1)	16 (45.8)	
Residence	Rural	38 (48.7)	29 (50.0)	16 (45.7)	0.582
	Urban	40 (51.3)	29 (50.0)	19 (54.3)	
Duration of symptoms	≤7 days	47 (60.3)	33 (56.9)	19 (54.3)	0.603
	>7 days	31 (39.7)	25 (43.1)	16 (45.7)	
Microorganism type	*S. pneumoniae*	46 (59.0)	33 (56.9)	15 (42.9)	0.137
	S. aureus	16 (20.5)	12 (20.7)	10 (28.6)	
	Others	16 (20.5)	13 (22.4)	10 (28.6)	

DISCUSSION

Cough (90.1%), fever (93.6%), and chest pain (78.9%) were the most frequent presenting symptoms among the 171 patients with pleural infection in our cohort. This clinical profile aligns closely with the original derivation of the RAPID score by Rahman *et al*.[14] in which a simplified set of routine clinical and laboratory variables reliably identified patients at risk for adverse outcomes. The RAPID score—based on renal function, age,

purulence of pleural fluid, infection source, and dietary status (serum albumin)—was specifically developed for bedside use and remains one of the few validated prognostic tools available for pleural infection.

Recent metagenomics advances reported by Kanellakis *et al*. [15] have deepened understanding of the polymicrobial nature of pleural infection, revealing mixed and novel microbial communities and reinforcing the importance of early, accurate risk stratification to guide therapy. Reflecting these trends, the joint ERS/ESTS statement by Bedawi *et al*.[16] now recommends the use of simple validated prognostic scores such as RAPID in the initial management of suspected empyema. Such early risk assessment allows clinicians to promptly identify high-risk patients who may benefit from early drainage, more aggressive antibiotic regimens, or expedited surgical referral.

In our study, patients categorized into higher RAPID categories demonstrated a clear, stepwise increase in both mortality and length of hospitalization, mirroring the external validation studies reported by Stüben *et al*.[17] across different health-care systems and populations. Furthermore, surgical series such as that of Carneiro *et al*.[18] have shown that incorporating comorbidities—including cardiovascular disease or immunosuppression—can enhance the predictive accuracy of the RAPID score, particularly in patients requiring operative management. These observations underscore the importance of determining the RAPID score at admission to guide decisions for chest tube drainage, escalation of care, or early surgical consultation. Integrating this score into routine clinical workflow could streamline triage and optimize the time to definitive treatment.

Age emerged as a significant predictor of mortality in our cohort. Patients older than 70 years were significantly more likely to fall into the high-risk RAPID category ($p = 0.014$), consistent with the observations of Elsheikh *et al*.[19] who highlighted the cumulative impact of aging, frailty, and comorbidity burden on outcomes in severe pleural infection. Age is a strong constituent of the RAPID score and has been repeatedly shown to predict poor outcomes in various clinical settings, as emphasized by Musher.[20]

While other demographic factors—including sex, place of residence, socioeconomic status, symptom duration, or infecting organism were not independently associated with mortality in our analysis, microbiological profiling was informative. Streptococcus pneumoniae was the most common pathogen, followed by Staphylococcus aureus, mirroring international data on the microbiology of pleural infection as summarized by Presti.[21] Next-generation sequencing (NGS) studies by Álvarez-Otero *et al*.[22] further complement conventional cultures by detecting fastidious or novel organisms, potentially influencing antibiotic selection and duration of therapy. These molecular techniques mark an important step toward personalized treatment based on a more comprehensive understanding of the pleural microbiome.

Collectively, these findings further validate the utility of the RAPID score as a point-of-care prognostic tool, even in the era of molecular diagnostics. Classic management reviews by Bhatnagar and Maskell[23] Management strategies continue to emphasize early drainage and intrapleural therapy in complex effusions—principles that remain relevant despite the advent of new evidence. Our regional microbiological results are concordant with the findings of Atif *et al*.[24] from Pakistan, who reported a comparable predominance of *Streptococcus pneumoniae* and related streptococcal species in empyema, supporting the external validity of our findings. Likewise, the pathophysiological insights highlighted by Porcel and Light[25] underscore the value of combining clinical risk scores with meticulous microbiological testing to optimize patient outcomes.

Despite these strengths, our study has limitations. Being a single-center analysis from a tertiary-care facility, generalizability may be limited, and

statistical power for subgroup analyses was constrained by the modest sample size. Late outcomes—such as relapse, pleural thickening, functional impairment, or quality-of-life measures—were not evaluated. Additionally, prior antibiotic administration, which can significantly reduce culture yield and obscure microbial patterns, was not systematically documented. Future multicenter studies should prospectively validate the RAPID score in larger, more diverse populations; explore the addition of imaging biomarkers or molecular microbiology data; and conduct cost-effectiveness analyses to determine whether routine RAPID scoring can reduce mortality, morbidity, and health-care resource utilization. Such efforts will help define the evolving role of RAPID and potential modifications as pleural infection management continues to advance.

CONCLUSION

Pleural infection in our setting is characterized by a high symptom burden, with cough, fever, and chest pain being the most prevalent symptoms. Older age was strongly associated with higher mortality risk according to the RAPID score ($p = 0.014$), highlighting the need for targeted early interventions in this group.

The RAPID score is an effective prognostic tool in our context. We recommend its routine incorporation into tertiary-care protocols. Further multicenter studies with long-term follow-up are warranted.

CONFLICT OF INTEREST

None

GRANT SUPPORT & FINANCIAL DISCLOSURE

Declared none

AUTHOR CONTRIBUTION

Arif Ul Islam: Substantial contributions to study design, acquisition of data, and analysis, manuscript drafting and reviewing it critically for important intellectual content, final approval, accountable for all aspects of publication.

Faisal Faiyaz Zuberi: Substantial contributions to concept and study supervision, Critical review of the manuscript for important intellectual content, final approval, accountable for all aspects of publication.

Feroz Raza: Substantial contributions to data acquisition and literature review, Analysis and interpretation of data, manuscript editing, final approval, accountable for all aspects of publication.

Sana Salari: Substantial contributions to data acquisition and manuscript formatting, Critical review of the manuscript for important intellectual content, final approval, accountable for all aspects of publication.

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