

ORIGINAL ARTICLE

Detection of causative organisms on bacterial culture in pleural tissue versus pus in patients with thoracic empyema.

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ABSTRACT... Objective: To determine the diagnostic yield of bacterial culture in pleural tissues and pus in patients with pleural empyema and assess the applicability of pleural biopsy in diagnosis. **Study Design:** Prospective Comparative Observational study, non-probability consecutive sampling. **Setting:** Department of Pulmonology Out Patients (OPD) and Indoor Wards, Shaikh Zayed Hospital, Federal Postgraduate Medical Institute Lahore, Pakistan. **Period:** Spanned 18-months, 21 October 2020 to 20 April 2022. **Methods:** The study included 75 consenting patients (18-70 years) with thoracic empyema, excluding those on antibiotics, with prior pus sample collection >1 week ago, or with pulmonary/extra-pulmonary tuberculosis. Pleural tissue and pus samples were collected for bacterial culture. Diagnostic yields were compared, and data stratified by age, gender, BMI, and symptoms duration, with statistical significance set at P value ≤ 0.05 . **Results:** The study included 75 patients with pleural empyema, with a mean age of 38.1 years and BMI of 25.4 kg/m². Males accounted for 65.3% of the cohort. Pleural tissue samples showed a higher diagnostic yield (84%) compared to pus samples (58.7%). BMI was significantly associated with pleural tissue yield ($p=0.040$). *Klebsiella* species, *Staphylococcus aureus*, *Streptococcus* species, and *E. coli* were the most common pathogens isolated from pleural tissues, while *Staphylococcus aureus* was most common in pus samples. **Conclusion:** Pleural biopsy with bacterial culture offers a higher diagnostic yield than pus culture alone in patients with thoracic empyema, enhancing diagnostic accuracy and informing treatment strategies effectively.

Key words: Bacterial Culture, Causative Organisms, Empyema, Pus, Pleural Tissue.

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INTRODUCTION

Pleural infection, a condition with a historical footprint tracing back to ancient Egypt circa 3000 BC, remains a prevalent and clinically significant entity in modern medical practice, necessitating prompt recognition and effective management to mitigate its considerable morbidity and mortality.¹ Empyema, characterized by the accumulation of pus in the pleural cavity, remains a significant contributor to global morbidity and mortality. While commonly complicating bacterial pneumonia, it can also stem from various other etiologies.² Other causes include penetrating chest trauma, pleural cavity inoculation post-tube thoracostomy or thoracocentesis, esophageal rupture, or lung surgery complications. Maintaining a high index of suspicion for empyema is vital, particularly in patients who are not responding to standard pneumonia treatment or those developing new pleural effusion on chest imaging (radiography or ultrasound).²

Diagnosing the underlying cause of empyema can be challenging, despite the presence of typical clinical symptoms, as conventional sampling methods, such as pleural fluid culture, often yield disappointing results, with a dismal 20-30% success rate in detecting the responsible organisms, thereby complicating targeted therapeutic interventions and emphasizing the need for more sensitive and effective diagnostic approaches.⁴ In cases of tuberculous (TB) pleural infection or empyema, pleural tissue culture demonstrates a significantly higher diagnostic yield, with a success rate of approximately 90%, whereas pleural fluid culture has a markedly lower yield of around 10%.⁵ The limited sensitivity of pleural fluid cultures in diagnosing TB stems from the tendency of *Mycobacterium tuberculosis* to localize primarily within the pleural tissue, rather than being present in the pleural fluid. As a result, pleural biopsy emerges as a more dependable and sensitive diagnostic approach, allowing for direct sampling of the

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infected tissue and thereby increasing the likelihood of detecting the causative organism. Pleural tissue bacterial culture obtained through pleural biopsy is a highly effective diagnostic method for identifying bacterial empyema, offering a more accurate diagnosis compared to other approaches.

Despite its potential, this technique remains underutilized in clinical practice, making it a valuable yet overlooked tool for diagnosing this serious condition. Despite its potential to enhance diagnostic accuracy, it remains infrequently employed in clinical practice, supplementing conventional approaches such as chest radiology and pleural pus culture, which highlights the need for increased awareness and adoption of this adjunctive diagnostic modality. Enhanced diagnostic approaches are likely to translate into improved treatment outcomes and prognosis for patients with pleural empyema. In a previous Danish study addressing incidence, length of stay, and prognosis of hospitalized patients with pleural empyema, it was shown that empyema incidence has risen over 15 years. This study uniquely examines nationwide 30-day mortality trends, revealing that comorbidity strongly influences short-term mortality. Notably, survival rates improved over time, despite increasing patient comorbidity with advanced age and comorbidity being the key prognostic factors, highlighting empyema's severity and need for prolonged hospitalization.⁷

Moreover, pleural effusion is a marker of advanced disease, with poor prognostic implications in patients with pulmonary infections, particularly when complicated by large empyemas. Reported mortality rates vary substantially, ranging from 1% in uncomplicated parapneumonic effusions to 30% in empyema, and escalating to 50% among ICU patients, underscoring the clinical severity of these conditions.⁸ Pleural infection exhibits distinct bacteriological profiles compared to pneumonia, necessitating tailored treatment approaches. Community-acquired infections typically require antibiotics targeting aerobic and anaerobic bacteria, whereas hospital-acquired infections, often involving gram-negative *S. aureus* and mixed aerobic pathogens, are associated with a high mortality rate, demanding prompt and effective therapeutic strategies.⁹

In patients with pulmonary parenchymal infections, pleural infection is a frequent complication, associated with a substantial burden of morbidity and mortality, exceeding 30%, particularly when the underlying pathogens include Gram-negative bacteria, *Staphylococcus aureus*, or mixed aerobic organisms. Notably, standard pleural fluid culture yields negative results in approximately 40% of cases, highlighting the limitations of conventional diagnostic approaches and underscoring the need for enhanced diagnostic strategies.¹⁰ Bacteria in empyema may lodge in pleural membranes, reducing the effectiveness of pus culture alone, as pleural tissue is hypothesized to be a suitable habitat for microbes to proliferate.^{3,6} This study compared pleural tissue culture with pleural pus culture to diagnose empyema, aiming to establish pleural biopsy's role in improving detection rates, as many pus organisms may be dead and undetectable, potentially leading to faster diagnosis and better treatment outcomes.

METHODS

This prospective comparative observational study, using non-probability consecutive sampling, was conducted in the Pulmonology Out Patients Department (OPD) and indoor wards at Shaikh Zayed Hospital, Lahore, Pakistan. The study took place over 18 months (21 October 2020 – 20 April 2022). The sample size of 75 empyema patients was calculated using the formula for estimating a population proportion, with a 95% confidence level, 9% margin of error, and an expected 19.2% positive bacterial culture on biopsy, yielding approximately 73.58, rounded up to 75 patients. The study included all consenting patients aged 18-70 years, both males and females, who presented with thoracic empyema (frank pus on pleural aspiration).^{3,5,6,9} Patients were excluded if they were already taking antibiotics or if their pus sample was also collected previously more than 1 week ago before presenting to our department or there was any evidence of pulmonary or extra-pulmonary tuberculosis.^{5,6,9}

Informed consent was obtained from all participants. Data were collected after obtaining informed written consent from patients. Demographic information (name, age, sex, BMI), symptoms, and durations were recorded on a pre-designed proforma. Empyema

procedures were done in the interventions room with full aseptic measures and local anesthesia (2% lignocaine 1-2 mg/kg) administered to the skin and intercostal space. Pleural tissue was collected using an Abrams pleural biopsy needle (5 passes) and tissue specimen placed in normal saline, alongside pus samples collected in a sterile 50 ml syringe. On site thoracic ultrasound was utilised to mark the site of pleural aspiration and biopsy and post-biopsy, a chest tube was placed at the same pleural puncture site as part of the routine management. Both pleural tissue and pus samples were sent to the hospital's microbiology laboratory for standard aerobic and anaerobic bacterial cultures and sensitivity testing to identify organisms. The type of bacterial growth was noted, and diagnostic yields were recorded.

Data were recorded using a pre-designed proforma. The collected data was analysed statistically by using SPSS version 20. Quantitative variables like age, BMI and duration of symptoms were calculated as mean and standard deviation. Qualitative variables like gender and diagnostic yield were calculated as frequency and percentage. Data was stratified for age, gender, BMI and duration of symptoms. Post-stratification, chi-square test was applied with p-value ≤ 0.05 as significant.

Study approval was done by Research Evaluation Unit, College of Physicians and Surgeons Pakistan reference number: CPSP/REU/PUL-2018-072-493. Informed consent was obtained from all participants, and the study conformed to the Helsinki Declaration of 1975, as revised in 1983.

RESULTS

Patient Demographics and Baseline Characteristics

A total of 75 patients were enrolled in the study (Table-I, Figure-1). The mean age of the participants was 38.1 years (SD $\pm$ 12.2), with a mean body mass index (BMI) of 25.4 kg/m² (SD $\pm$ 3.12). The mean duration of symptoms prior to presentation was 4.5 weeks (SD $\pm$ 1.24). The study population comprised a majority of male patients (65.3%, n=49), while

females accounted for 34.7% (n=26) of the cohort.

Diagnostic Yield and Stratified Analysis

The overall diagnostic yield (Table-I, Figure-1) was higher for pleural tissue samples (84%) vs pus samples (58.7%). Stratified analysis assessed demographic and clinical factors' influence on yield. No significant association was found between age, gender, or symptom duration and yield of either sample. A significant association was observed between BMI and pleural tissue yield (p=0.040). Diagnostic yield for both samples was highest among late middle-aged patients (pleural tissue: 44%; pus: 29.3%). Males had a higher yield than females for pleural tissue (53.3% vs 30.7%) and pus (36% vs 22.7%). Patients with symptoms lasting 4-8 weeks had higher yields (pleural tissue: 64%; pus: 40%). Overweight patients had the highest pleural tissue yield (38.7%), while normal BMI patients had the highest pus yield (26.7%).

Microbiological Profile of Pleural Tissue and Pus Samples

Analysis of pleural tissue samples revealed a broad spectrum of bacterial pathogens. The most frequently isolated organisms in tissue cultures (Figure-2) were Klebsiella species (14.7%), Staphylococcus aureus (13.3%), Streptococcus species (10.7%), and Escherichia coli (9.3%). Other identified pathogens included Enterococci (8%), Enterobacteria species (8%), and Anaerobes (8%), followed by Haemophilus influenzae (6.7%), Methicillin-Resistant Staphylococcus aureus (MRSA) (4%), and Streptococcus pneumoniae (1.3%). No bacterial growth was observed in 16% of pleural tissue samples.

In comparison, culture of pus samples (Figure-3) demonstrated a different microbiological distribution, with Staphylococcus aureus (13.3%) being the most common isolate, followed by Klebsiella species (10.7%), Streptococcus species (9.3%), and E. coli (8%). Other organisms cultured from pus included Enterococci (5.3%), Enterobacteria (4%), Anaerobes (2.7%), H. influenzae (2.7%), MRSA (1.3%), and S. pneumoniae (1.3%).

TABLE-I			
Patient demographics and diagnostic yield			
Parameter		Pleural Tissue (n=75)	Pus (n=75)
Patient Demographics	Total Patients (N)	75 (100%)	
	Mean Age (Years)	38.1 (±12.2)	
	Sex	Male: 49 (65.3%)	
		Female: 26 (34.7%)	
	Mean BMI (kg/m²)	25.4 (±3.12)	
	Mean Symptom Duration (Weeks)	4.5 (±1.24)	
Diagnostic Yield	Overall Positive Yield	63 (84.0%)	44 (58.7%)
Yield by Age Group	Late Middle-Aged	33 (44.0%)	22 (29.3%)
Yield by Sex	Males	40 (53.3%)	27 (36.0%)
Yield by Symptom Duration	Longer (4 - 8 Weeks)	48 (64.0%)	30 (40.0%)
Yield by BMI Category	Overweight	29 (38.7%)	-
	Normal weight	-	20 (26.7%)
Statistical Significance	Association with BMI	p = 0.040	

FIGURE-1
p-test results for selected risk factors in diagnostic yield in pus and pleural tissues. A correlation showing p<0.05 shows statistical significance.

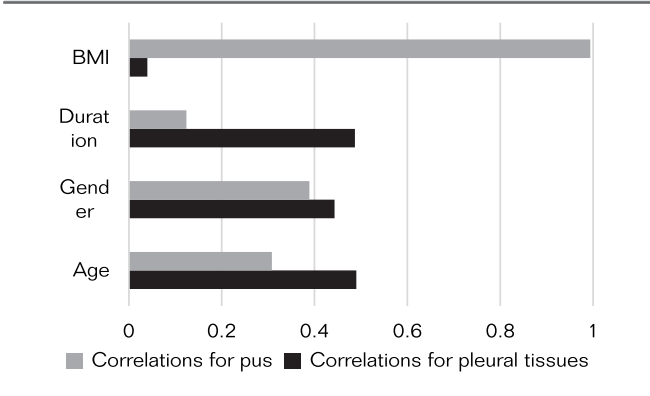


FIGURE-2
Cumulative chart for bacterial culture found in pleural tissue sample.

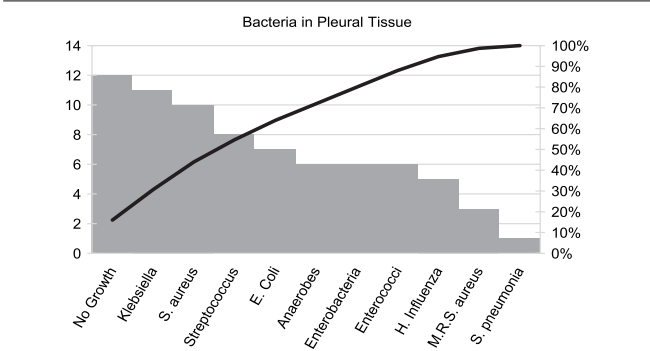
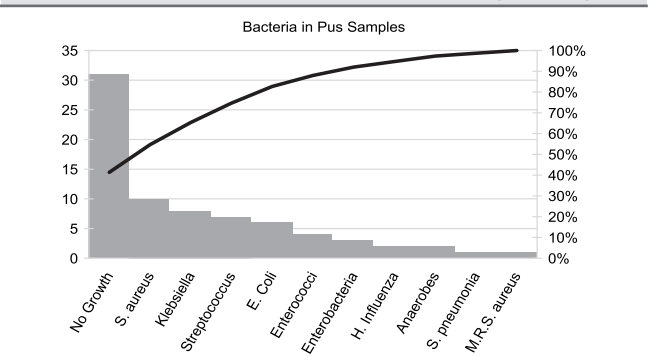


FIGURE-3
Cumulative chart for bacterial culture found in pus samples.



DISCUSSION
Pleural infections like empyema and complicated parapneumonic effusion are a significant health concern, affecting around 80,000 patients each year in the US and UK.⁷ Pus culture is a key diagnostic tool for identifying the cause of empyema thoracis, but analyzing pleural tissue can provide additional valuable information for accurate microbiological diagnosis. By examining pleural tissue, healthcare providers can gain a more comprehensive understanding of the infection, enabling targeted antibiotic therapy and potentially improved patient outcomes.¹¹ This study compared the diagnostic effectiveness of pleural tissue biopsy and pus culture in empyema patients, revealing that pleural tissue

sampling had a significantly higher diagnostic yield (84%) than pus culture (58.7%). This discrepancy underscores the limitations of relying solely on pus analysis for diagnosing pleural infections, emphasizing the potential value of incorporating pleural biopsy into diagnostic protocols. By doing so, clinicians could enhance diagnostic accuracy, particularly in cases with sterile pus cultures or when common pathogens are suspected but not isolated. Integrating biopsy results could guide more targeted and effective treatment strategies, improving patient outcomes. The added yield from biopsy may be especially valuable in regions where antibiotic resistance is common, informing optimal therapeutic approaches.^{9,10,11}

Many conventional notions about pleural infection are based on outdated assumptions rather than empirical evidence, having been adopted without rigorous scrutiny or validation. Dissecting evidence and challenging established concepts are crucial for advancing our understanding and management of pleural infections. By scrutinizing existing practices and embracing new findings, we can refine diagnostic approaches, develop more effective treatments, and ultimately improve patient outcomes.^{8,10,11} Empyema is diagnosed when pus or bacteria are present in the pleural fluid, and determining the underlying cause is crucial for selecting the most effective antibiotic treatment. Identifying the specific pathogen causing empyema allows healthcare providers to customize antibiotic treatment, leading to better patient outcomes, reduced complications, and more effective management of the infection.^{10,11} The sensitivity of pus culture in diagnosing empyema is notably limited, identifying the causative pathogen in approximately 60% of cases, as reported by Maskell et al.⁹ This is consistent with our study's findings, where pus culture was positive in 58.7% of cases, leaving a significant proportion undiagnosed. This gap illustrates the critical need for supplementary diagnostic approaches, such as molecular techniques or pleural biopsy, to enhance pathogen detection and facilitate targeted, effective therapy. To enhance diagnostic yield, it is recommended that pleural fluid be inoculated directly into blood culture bottles (both aerobic and anaerobic) in conjunction with standard sterile containers for Gram staining and culture, a practice not evaluated in the present

study.¹⁰ Recent studies, including ours, emphasize the difficulty in identifying causative organisms in pleural infections, with approximately half of cases yielding negative cultures using conventional methods, emphasizing the need for more sensitive diagnostic approaches.^{10,11}

Pleural tissue culture outperforms pus culture in detecting pathogens, with 60.9% positivity compared to 52.1% for pus culture, aligning with our study's findings and indicating a growing preference for tissue culture in empyema diagnosis.^{6,11} Pleural tissue culture's benefits are largely supported by studies on pleural TB diagnosis. The utility of pleural tissue culture is well-established in pleural TB diagnosis, where it significantly outperforms fluid culture. Specifically, pleural fluid culture is positive in only 20-30% of patients, whereas pleural biopsy histopathology yields a diagnostic rate of 60-95%, and culture of pleural biopsy material is positive in 40-80% of cases. This substantial difference highlights the value of pleural tissue for microbial culture, supporting its use in empyema diagnosis to enhance pathogen detection.¹² Our findings advocate for the inclusion of pleural tissue sampling as a complementary diagnostic modality in empyema, potentially enhancing pathogen yield and guiding targeted therapy, especially in culture-negative cases or complex presentations. Pleural tissue can be obtained through various methods, including thoracoscopy, which allows direct visualization and sampling, ultrasound-guided pleural biopsy, a minimally invasive procedure with high yield, and closed percutaneous Abrams needle biopsy, a simple and effective technique. Ultrasound-guided trans-thoracic needle biopsy is commonly used for diagnosing pleural masses, but its application in thoracic empyema patients is less explored, highlighting a need for more research in this area.¹³ In our research, Abrams needle biopsy was selected for pleural tissue sampling due to its practical advantages, including easy availability, cost-effectiveness compared to trucut ultrasound-guided biopsy, and less invasiveness compared to medical thoracoscopic pleural biopsy, making it a suitable choice for empyema diagnosis in our setting.¹⁴

Our study showed an 84% yield from pleural tissue

bacterial culture (via Abrams needle biopsies), surpassing the 45% yield reported in the AUDIO study by Psallidas et al, where ultrasound-guided (US) pleural tissue biopsies outperformed pleural fluid and blood cultures (20% and 10%, respectively).⁶ We enrolled 75 patients, whereas the AUDIO study had 20 patients with established pleural infection. Both studies performed pleural biopsies before chest drain insertion, but the AUDIO study also included blood cultures and pleural fluid microbiological analysis. Although our study excluded patients on antibiotics, the AUDIO study found pleural tissue culture was the only positive test in 25% of patients, with 75% of these patients already on antibiotics, highlighting the value of pleural biopsy even on antimicrobial therapy. US-guided pleural biopsies were safe with no adverse events, similar to our study where we used Abrams biopsy with site confirmation via on-site thoracic ultrasound in all patients.⁶

Our findings echo Kim CH et al.'s Korean study, indicating age and gender aren't associated with positive culture rates. Notably, our study uniquely identified a link between BMI and higher diagnostic yield of pleural tissue biopsy, whereas other factors like cavitory lesions and RAPID score were associated with bacteremia in different contexts, highlighting the potential relevance of BMI in optimizing biopsy outcomes.¹⁵ Research exploring the interplay between obesity and infections reveals that elevated BMI is correlated with increased infection severity, diminished vaccine efficacy, and altered responses to antimicrobial therapy. This complex relationship suggests obesity may compromise immune responses and modify treatment outcomes, potentially leading to more challenging infection management in obese individuals.¹⁶ The suboptimal yield of conventional culture methods, consistently observed across populations and highlighted by studies exploring enhanced techniques, emphasizes the necessity for improved diagnostic approaches, such as the tissue biopsy method evaluated in our study, to boost pathogen detection in pleural empyema patients.⁶

Empyema involves bacterial invasion of the pleura, but the exact mechanisms of pleural infection are still unclear. Research suggests a

multifaceted interaction between microbial, host, and environmental factors, moving beyond the traditional view of direct spread from pneumonia, and indicating a more complex pathogenesis.^{11,15,17} Patients with symptoms persisting for 4-8 weeks exhibited higher diagnostic yields, with pleural tissue culture positivity at 64% and pus culture at 40%, indicating that longer symptom duration may enhance the likelihood of obtaining positive culture results. This likely reflects increased bacterial proliferation and inflammation in chronic infections, improving detection. The higher diagnostic yield observed in late middle-aged patients, with pleural tissue culture positivity at 44% and pus culture at 29.3%, is consistent with the demographic profile of pleural infection, which typically affects older adults, suggesting age-related factors may contribute to increased susceptibility and diagnostic yield in this group. Despite our cohort's younger mean age of 38.1 years, contrasting with studies like the Portuguese study (mean age 65 years), the observed age-related trend aligns with pleural infection epidemiology, suggesting age influences disease susceptibility and diagnostic outcomes, even if our population is atypical.¹⁸

Streptococcus pneumoniae, a major pneumonia pathogen worldwide, frequently causes parapneumonic effusions and empyema, accounting for 10-20% of culture-positive cases, reflecting its prominent role in respiratory infections and highlighting its propensity to complicate pneumonia with pleural involvement.^{19,20} In contrast to the predominance of *Streptococcus pneumoniae* in many settings, our study identified *Klebsiella pneumoniae* as the most common pathogen, followed by *Staphylococcus aureus*, *Streptococcus* species, and *E. coli*, suggesting regional or population-specific differences in microbiological patterns of pleural infections. The detection of virulent pathogens, including MRSA, in Pakistani studies indicates that unchecked antibiotic use likely fuels drug resistance, complicating treatment and emphasizing the need for judicious antimicrobial stewardship to curb resistance patterns.^{21,22,25} A landmark systematic review by Hassan et al., encompassing 10,241 patients from 75 studies, revealed *Staphylococcus aureus* as the predominant organism causing pleural infections worldwide, highlighting its significant role

in pleural empyema. Our study supports global trends, with *Staphylococcus aureus* among the top isolates in both pleural tissue and pus. Notably, *Klebsiella* species were more prevalent in our cohort, likely reflecting geographical differences in microbial epidemiology, highlighting the importance of local microbiological patterns in guiding empirical therapy.²² Our 16% culture-negative rate aligns with existing literature, which reports up to 23.53% of pleural biopsies lacking diagnostic microbiological findings, emphasizing the challenges of pathogen detection and the potential need for advanced diagnostics to improve yield.²³ Compared to our study, in a local Pakistani study by Tareen et al, among 42 empyema cases (11 culture-positive, 31 culture-negative), only 11 (26%) yielded bacterial growth, predominantly Gram-negative enteric rods, with *Streptococcus pyogenes* isolated from two samples.²⁴ A local pediatric study by Raza et al. found community-acquired bacterial pneumonia responsible for 90% of empyema thoracis cases, with *Staphylococcus aureus* being the most common isolate (32%), mirroring global trends and highlighting its significant role in pediatric pleural infections.²⁵ Atif et al.'s study on empyema thoracis found cultures positive in 58 (52.7%) of 110 patients. *Pseudomonas aeruginosa* (18.8%), *Klebsiella* species (10%), and *E. coli* (10%) were the predominant isolates, exhibiting significant resistance to broad-spectrum antibiotics, complicating treatment approaches.²⁶ Khan et al.'s study of 25 empyema thoracis patients in Pakistan showed Abrams pleural biopsy effectively diagnosed tuberculous empyema, especially when pus cultures were sterile. This underscores its importance in TB-endemic regions where conventional cultures may fail to identify the pathogen. The biopsy's contribution to diagnostic yield highlights its role in guiding targeted therapy. Unlike our study where *Klebsiella pneumoniae* dominated, they found *Pseudomonas aeruginosa* most common (32%), followed by similar isolates: *E. coli* (20%), *Staph. aureus* (16%), *Strep. pneumoniae* (8%), and *H. influenzae* (8%).²⁷ A large study of 294 empyema thoracis patients revealed community-acquired infections predominated (72.2%), with *Klebsiella pneumoniae* the most common pathogen, aligning with our findings where *Klebsiella pneumoniae* topped the list and males were disproportionately

affected. Risk factors for adverse outcomes included male gender, rural residency, smoking, and biomass exposure, consistent with our male-predominant culture-positive cases. These shared trends highlight vulnerable populations and potential targets for prevention.²⁸ A systematic review of 75 studies (10,241 adults, 2000-2018) identified *Staphylococcus aureus* as the leading global pathogen in pleural infections. Regional trends showed pneumococci and viridans streptococci dominating in tropical and temperate zones, respectively. Hospital-acquired infections exhibited higher rates of Gram-negative and drug-resistant isolates. In contrast, our Pakistani study found *Klebsiella pneumoniae* most prevalent, followed closely by *Staphylococcus aureus* (second most common), aligning with some Asian trends. This highlights significant geographical variation, with local epidemiology, healthcare practices, and environmental factors likely shaping pathogen distribution.²² Moreover, a recent study shows that bacteria including *Streptococcus mitis*, *Streptococcus pneumoniae*, *Staphylococcus aureus*, and *Pseudomonas aeruginosa* can aggregate in pleural fluids, particularly under dynamic conditions, leading to enhanced antibiotic resistance.²⁹ Apart from the cultures molecular techniques like PCR and antigen detection can boost diagnostic yield, particularly for *Streptococcus pneumoniae*, *Streptococcus pyogenes*, and *Staphylococcus aureus*. In one pediatric study (n=78), direct culture identified pathogens in 45% of pleural empyema cases, rising to 73% with PCR on culture-negative samples. Pneumococcal antigen detection via latex agglutination showed 95% positive and 90% negative predictive value, enabling rapid pneumococcal empyema diagnosis.³⁰

CONCLUSION

Pleural tissue sampling through biopsy emerges as a valuable diagnostic approach in patients with empyema, offering a higher yield compared to conventional methods. By facilitating early diagnosis and targeted intervention, pleural biopsy holds promise for mitigating the considerable morbidity and mortality associated with empyema. In line with the study's objectives, the findings emphasize the utility of pleural tissue bacterial culture in enhancing diagnostic accuracy. However, further research is

warranted to elucidate the aetiological spectrum of empyema, optimize diagnostic algorithms, and inform evidence-based management strategies, ultimately improving patient outcomes.

LIMITATIONS

This study has several limitations that warrant consideration. The relatively small sample size and single-center design may limit the generalizability of the findings to broader populations. Furthermore, the study did not differentiate between community-acquired and hospital-acquired infections, which could have distinct epidemiological and microbiological profiles. The absence of bacterial PCR and histopathological examination may have contributed to underdiagnosis, particularly in culture-negative cases, some of which might have been attributable to tuberculosis or other pathogens. These methodological constraints underscore the need for larger, multicenter studies incorporating comprehensive diagnostic modalities to more accurately define the spectrum and management of pleural infections.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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AUTHORSHIP AND CONTRIBUTION DECLARATION

1	Iqra Anwar: Conception, design.
2	Talha Mahmud: Data collection, supervision.
3	Muhammad Saqib: Interpretation of data.
4	Mohammad Ramzan: Discussion, proof reading.
5	Faisal Iqbal: Interpretation of data.
6	Abdul Saeed Khan: Data analysis.