

Bacteriological Profile and Antibiotic Resistance of Pleural Infections: A literature Review

Profil bactériologique et résistance aux antibiotiques des infections pleurales: Une revue de la littérature

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ABSTRACT

Pleural infection remains a medical challenge with serious consequences for the health and lives of individuals worldwide. The diagnosis of pleural effusion (PE) infection shows that the isolated micro-organisms exhibit substantial resistance to standard prescribed antibiotics. Therefore, the selection of appropriate antibiotics for treatment should be based on microbiological findings. Understanding the microbiology of pleural infections is essential for making informed choices about antibiotic therapy. The objective of this review is to analyze studies that have attempted to identify the types of bacteria involved, antibiotic sensitivity and resistance profiles, factors associated with pleural infections. Studies showed that bacteria isolated from pleural effusion have shown increasing antibiotic resistance, which should influence the choice of empirical antimicrobial therapy. This also highlights the importance of closely monitoring the dissemination and emergence of drug-resistant bacterial agents.

Keywords: Pleural infection, microbiological profile, antibiotic resistance.

RÉSUMÉ

L'infection pleurale reste un défi médical avec de graves conséquences pour la santé et la vie des individus dans le monde entier. Le diagnostic d'une infection par épanchement pleural (EP) montre que les micro-organismes isolés présentent une résistance substantielle aux antibiotiques prescrits standard. Par conséquent, la sélection des antibiotiques appropriés pour le traitement doit être basée sur les résultats microbiologiques. La compréhension de la microbiologie des infections pleurales est essentielle pour faire des choix éclairés en matière d'antibiothérapie. L'objectif de cette revue est d'analyser les études qui ont tenté d'identifier les types de bactéries impliquées, les profils de sensibilité et de résistance aux antibiotiques, facteurs associés aux infections pleurales. Les études ont montré que les bactéries isolées à partir d'épanchements pleuraux ont montré une résistance croissante aux antibiotiques, ce qui devrait influencer le choix du traitement antimicrobien empirique. Cela souligne également l'importance de surveiller de près la dissémination et l'émergence d'agents bactériens résistants aux médicaments.

Mots clés: Infection pleurale, profil microbiologique, résistance aux antibiotiques.

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INTRODUCTION

Pleural effusion (PE) is characterized by an excessive accumulation of exudate or transudate in the pleural cavity, resulting from various pathological conditions. PE can arise from various causes, with the most common being congestive heart failure, infections, inflammatory disorders and cancers (1–3).

Pleural infections remain a common medical problem, affecting individuals of all ages, with a high incidence among elderly and children (4–6). They have a significant impact on the health of patients. Despite advances in healthcare and medical progress, this infection remains an important clinical problem in the 21st century (7,8). The global rate of pleural infections caused by bacteria has increased from 7.6% to 14.9%, with a mortality rate of 20% (8,9). Approximately 40% of lung cancer patients develop pleural effusions during their disease course, with malignant pleural effusions being associated with poor prognosis and reduced survival (10).

Clinically, people with pleural effusion may experience various clinical symptoms, depending on the underlying causes and the amount of fluid accumulated. Manifestations of pleural infections can vary widely, from asymptomatic viral pleurisy to severe dyspnea in cases of decompensated heart failure or tumor pathology. In addition, patients with pleurisy may experience localized pain, which varies in intensity (11,12). Approximately 15% of people with pleural infections who consult a healthcare professional have a serious condition (13).

Pleural infection may be limited to a specific area or disseminate throughout the pleural cavity, leading to "parapneumonic effusion" (5,13). In the elderly or those with chronic conditions, the risk of mortality from bacterial pleural infection varies between 25% to 75% (8,13–15).

Prognostically, pleural effusion can markedly increase the risk of mortality in affected patients. Studies have demonstrated an increased risk of mortality in patients with non-malignant pleural effusion within the first year following the event. Consequently, comprehensive evaluation and timely intervention are essential for the effective management of these patients.

The diagnostic of pleural effusion typically involves imaging techniques, thoracentesis or aspiration, and various biological tests, including cytological, microbiological, and biochemical analyses (16,17). In addition to treating the underlying cause, the treatment of pleural effusion (PE) infection includes chest tube drainage coupled with antibiotic therapy. In cases where patients do not respond to initial treatment, thoroscopic interventions or surgical procedures may be necessary (1).

The selection of antibiotics for treating pleural effusion (PE) infections should be based on microbiological findings, including culture findings when available. Recent guidelines suggest for empirical antibiotic therapy in patients with pleural effusion (PE) who have negative culture results. These guidelines recommend that antibiotic selection should account for whether the infection is community-acquired or hospital-acquired, as well as the local bacterial resistance patterns.

However, previous studies have noted that a substantial proportion of PE cases exhibit resistance to commonly used antibiotics., and the pathogens responsible for PE infections can vary geographically (4,18–20).

The objective of our study is to deepen our knowledge of the bacterial agents involved in PE infections and their antibiotic susceptibility.

BIBLIOMETRIC ANALYSIS

Our study is a literature review based on the search engines Science Direct and Google Scholar. It focused on a set of articles dealing with the study of the bacteriological profile and the sensitivity of germs isolated from pleural fluid samples. In parallel, a bibliometric analysis was carried out on "SCOPUS (<https://www.scopus.com/>, consulted on February 28, 2024)" database. Bibliometric data were extracted from 1279 published articles whose search equation used in our research included: "Human" AND ("infection" OR "bacteria" OR "germs" OR "pathogen" OR "microorganism") AND ("Pleurisy" OR "pleural effusion") AND ("Diagnostic" OR " analysis" OR "Microbiological analysis" OR "Detection" OR "isolation") AND ("antibiotic" OR "resistance" OR "Sensibility" OR "susceptibility"). Bibliometric analysis was performed using VOSviewer (v1.6.9, Leiden University, Leiden, Netherlands). In Figure 1, colors represent clusters of related terms, the size of a term label indicates the number of publications associated with that term, and the distance between terms reflects their level of association.

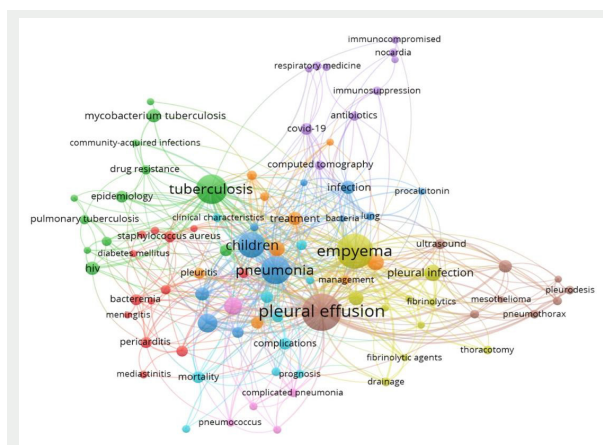


Figure 1. Bibliometric analysis of 1279 articles published on pleural infection according to the Scopus database using specific keywords such as "Human" AND ("infection" OR "bacteria" OR "germs" OR "pathogen" OR "microorganism") AND ("Pleurisy" OR "pleural effusion") AND ("Diagnostic" OR " analysis" OR "Microbiological analysis" OR "Detection" OR "isolation") AND ("antibiotic" OR "resistance" OR "Sensibility" OR "susceptibility")

PATHOPHYSIOLOGY

The normal pleural space contains up to 0.26 mL/kg of pleural fluid, regulated by the parietal pleural. Disruptions in this balance, influenced by Starling's forces, can lead to pleural effusion. In pleural infections, increased mesothelial permeability and bacterial invasion cause

an exudative effusion that exceeds drainage capacity. Around 20%–50% of community-acquired pneumonia (CAP) cases develop parapneumonic effusion, though only a few progress to overt infection. Risk factors remain unclear, but incidence is higher in older adults due to multimorbidity and immunosuppression, contributing to increased mortality (21,22).

Pleural infections often result from bacterial invasion of the sterile pleural space or infection spread from the abdomen. They are linked to pneumonia (both community- and hospital-acquired), chest trauma, tube drainage, postoperative complications, immunodeficiency, alcohol abuse, and smoking (23). Between 20%–57% of bacterial pneumonia cases lead to parapneumonic effusions, with a mortality rate of 15%–20% [20]. These infections account for 30% of thoracic surgery complications, with 15%–40% requiring surgical intervention, increasing risks (24).

DIAGNOSIS METHODS OF PLEURAL INFECTIONS

Diagnosis of pleural infections based on pleural fluid puncture

A persistent challenge in treating pleural infections is the difficulty in identifying the responsible microorganism. This challenge is often due to a combination of factors, including prior antibiotic treatment, low bacterial concentration in the pleural fluid, and the stringent criteria required for isolating causative agents in the laboratory. Typically, pleural fluid in infections is acidic, hypoxic, and nutritionally depleted. Bacterial concentration is generally higher in cases where the fluid exhibits increased purulence (25). A study investigating 172 pleural fluid samples showed that pH, glucose, and LDH levels were closely correlated with bacterial concentration when considered in the relevant clinical context. Notably, WBC (white blood cell count) and CRP (C-reactive protein) levels were of critical importance. (26).

Diagnosis of pleural infections on pleural biopsy

The routine practice of pleural tissue biopsy in endemic regions for suspected tuberculosis-related effusions, and for the evaluation of other causes of pleural diseases, has been long established. A recent study (27) suggests that this procedure might soon be widely adopted for non-tuberculous pleural infections as well. Psallidas et al. (28) performed ultrasound-guided pleural biopsies on patients with a prior diagnosis of pleural infection during chest drain insertion. The material obtained was subjected to microbiological examination after being placed in "normal" saline solution at 0.9%.

Microbiological diagnosis

Patients with pleural effusion often have pleural

infection, which requires prompt initiation of intensive antimicrobial therapy. Therefore, it is crucial to identify the responsible organisms to guide antibiotic selection and improve patient outcomes (29). Within the microbiology laboratory of Mohammed VI University Hospital, Oujda, pleural fluid samples submitted for cytobacteriological examination are processed according to REMIC recommendations (30) (Figure 2).

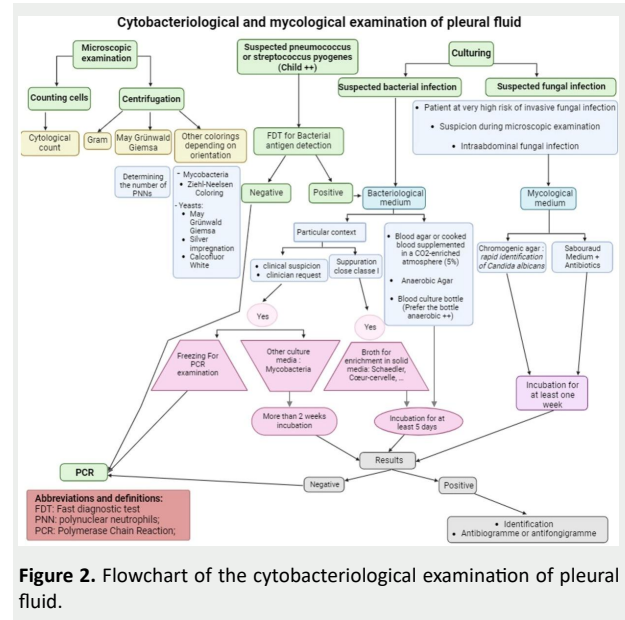


Figure 2. Flowchart of the cytobacteriological examination of pleural fluid.

Culture positivity rates for pleural fluid samples vary across studies. A recent study in Egypt reported a 47% positivity rate (31). In Ethiopia, reported rates ranged from 23.7% to 27.6% (32), while studies in India found 25.3% and 30.3% (33). In Pakistan, values were 23.2% and 32.9% (23), whereas higher rates were observed in Nigeria (43.8%) and northeastern India (37.3%) (18). These variations may result from differences in study populations and the lack of molecular diagnostic methods, which could improve pathogen detection, even in previously treated patients.

The application of PCR has proven to be a reliable supplement to traditional culture methods for diagnosing infections such as infective endocarditis and bone infections. This method was prospectively evaluated for pleural infections at two major Spanish university hospitals, where it was incorporated into routine laboratory procedures. Compared to standard culture, PCR improved sensitivity for pleural infections by approximately 50%, while maintaining the same specificity. (34).

INVOLVED PATHOGENS

The most common pathogens associated with community-acquired pneumonia include *Streptococcus pneumoniae* along with atypical bacteria such as *Legionella* and *Mycoplasma* spp. However, the pathogenic profile differs significantly in the context of pleural infections. Studies applying molecular methods for pathogen identification in infected pleural fluid samples revealed the presence of

atypical bacteria in only 0 to 0.5% of cases (29).

The systematic review also noted significant variations in pathogen isolation rates between community-acquired and healthcare-associated infections (13). In a recent study, pleural fluid culture results from 974 patients (35) from three major pleural infection studies were aggregated to expose the predominant organisms in community-acquired and nosocomial pleural infections (36). The most common aerobes encountered in community-acquired infections included streptococques viridans (25%), *S. pneumoniae* (23.8%), *Staphylococcus aureus* (14.5%), and Enterobacteriaceae (7.5%). For nosocomial infections, the dominant aerobes were *S. aureus* (45%), Enterobacteriaceae (19.6%), Streptococques viridans group (9%), and *Pseudomonas* spp (6.5%). Anaerobic bacteria were identified in 18% of community-acquired infections and 11% of nosocomial infections. In developing countries, pleural infections are more often caused by bacteria such as *Staphylococcus aureus*, *S. pyogenes*, *S. pneumoniae*, *E. coli*, *Haemophilus influenza*, *Klebsiella* spp and *Pseudomonas* spp (4). The role of these microbes as etiological agents in pleural infections could be explained by their ability to quickly colonize the body surface of a weakened host once displaced, as well as their capacity to survive in community and hospital environments by developing resistance to antimicrobials and disinfectants (19).

Staphylococcus aureus is the most frequently isolated agent in many studies, with varying reported rates. A study conducted in Africa and Asia showed that *S. aureus* is more commonly involved in pleural infections than *Streptococcus pneumoniae*, due to its association with thoracic empyema, often linked to low socioeconomic status, malnutrition, and delayed diagnosis (4). In contrast, *S. pneumoniae* is less frequently isolated, likely due to vaccination, advancements in diagnostic methods, and the early treatment of respiratory infections it causes, reducing its identification in pleural infections (24).

In some studies, particularly from low- and middle-income countries, there is a notable shift with the emergence of gram-negative bacteria as significant agents in various thoracic infections (37). For instance, a study in India reported that gram-negative bacilli were present in two-thirds of samples from patients with pleural effusion (PE) (37). Similarly, a report from Romania reported that gram-negative bacilli accounted for nearly half of the isolates in patients with PE (38).

Regarding the results of studies conducted in Casablanca, Morocco, a retrospective study of 128 cases identified the responsible germ in only 25% of cases. The germs identified were *Streptococcus pneumoniae* in 12% of cases, *Streptococcus* spp. in 7% of cases, GNB in 4% of cases, *Pseudomonas aeruginosa* and *Mycobacterium tuberculosis* in 2% of cases for each. Methicillin-resistant staphylococcus was noted in only one patient monitored for Alport's disease (39).

ANTIBIOTIC THERAPY AND THE RISE OF RESISTANCE

In the early stages of pleural infections, antimicrobial therapy, with or without chest tube drainage, is the preferred treatment (1,4). However, rising antibiotic resistance poses a major challenge (9). This resistance is linked to factors such as excessive use of broad-spectrum antibiotics, lack of diagnostic tests, absence of treatment guidelines, self-medication, and inadequate hospital control measures (4,9,32).

In a study conducted in Ethiopia, the analysis of antibiotic sensitivity revealed that over half of the isolated Gram-positive bacteria were resistant to chloramphenicol (51.5%), doxycycline (57.6%), and tetracycline (63.6%). However, a significant proportion of Gram-positive bacteria showed relatively high sensitivity to clindamycin (54.5%) and erythromycin (57.6%). *S. aureus* strains exhibited resistance exceeding 66.7% to penicillin, tetracycline, and doxycycline.

Regarding other types of germs, the study conducted in Ethiopia found that 20% of the isolated Enterococcus species were vancomycin-resistant (VRE). Additionally, 80% of the isolated Enterococcus species exhibited resistance to penicillin, tetracycline, and chloramphenicol. In contrast, all isolated strains of *S. pneumoniae* and *S. pyogenes* were sensitive to penicillin, erythromycin, cotrimoxazole, and vancomycin. These results are consistent with studies conducted in India (40) and Nigeria (9). However, investigations in India (41) and Ethiopia (32) showed higher resistance of isolated Gram-positive bacteria to cotrimoxazole, erythromycin and clindamycin. Higher prevalences were reported by Anand et al. (21) who used PCR to amplify the *mecA* gene on fifty strains of *S. aureus* and found that 32 isolates were positive for the *mecA* gene, with a prevalence of MRSA of 64%.

In the study conducted in Ethiopia, isolated Gram-negative bacteria showed resistance to ampicillin (60%), cefuroxime (60%) and ciprofloxacin (60%). However, gentamicin (60%) and meropenem (60%) remained effective against these bacteria. *E. coli* strains demonstrated high resistance to ampicillin (80%), while 66.7% of *K. pneumoniae* strains were resistant to ampicillin, ciprofloxacin, tetracycline, doxycycline and ceftriaxone. Piperacillin (100%) was effective against *P. aeruginosa* isolates, whereas ceftazidime was not. Similar patterns of antibiotic resistance have been reported in studies conducted in India (41) and Nigeria (9) report more or less similar values, but older studies in Ethiopia (32) indicated that Gram-negative bacteria isolated from various sterile body fluids exhibited resistance to gentamicin and chloramphenicol. The results described in the literature suggest that the commonly prescribed antibiotics are probably not the best choices for empirically treating pleural infections related to Gram-negative bacteria.

The rise of multidrug-resistant bacteria exacerbates the issue, particularly in developing countries, where challenges such as hospital overcrowding, inappropriate use of antibiotics, increased self-medication, and

insufficient infection prevention programs contribute to the problem. (32). On the other hand, it is imperative to quickly identify the infectious organism and implement the proper treatments (4–7,32).

CONCLUSION

Pleurisy, a critical medical condition requiring immediate attention, remains a significant concern in healthcare. Recent advancements continue to shed light on the pathogenesis, emphasizing key factors such as the host, bacteria, and pleural environment. Microbiological variability, influenced by evolutionary processes, affects patient outcomes and highlights persistent challenges, including delays in diagnosis, inadequate microbiological analysis, and the prevalence of polymicrobial infections. Furthermore, the integration of artificial intelligence and novel imaging techniques into bacterial identification has proven to be a major breakthrough, enhancing the speed, accuracy, and efficiency of diagnosing bacterial infections. Moving forward, it is crucial to prioritize improvements in diagnostic processes and adopt innovative technologies to optimize patient care and outcomes.

REFERENCES

- Tian P, Qiu R, Wang M, Xu S, Cao L, Yang P, et al. Prevalence, causes, and health care burden of pleural effusions among hospitalized adults in China. *JAMA Netw Open*. 2021;4(8):e2120306–e2120306.
- Ferreiro L, Porcel JM, Valdés L. Diagnosis and management of pleural transudates. *Arch Bronconeumol (English Ed)*. 2017;53(11):629–36.
- Karki A, Riley L, Mehta HJ, Ataya A. Abdominal etiologies of pleural effusion. *Disease-a-Month*. 2019;65(4):95–103.
- Hassan M, Cargill T, Harriss E, Asciak R, Mercer RM, Bedawi EO, et al. The microbiology of pleural infection in adults: a systematic review. *Eur Respir J*. 2019;54(3).
- Cargill TN, Hassan M, Corcoran JP, Harriss E, Asciak R, Mercer RM, et al. A systematic review of comorbidities and outcomes of adult patients with pleural infection. *Eur Respir J*. 2019;54(3).
- Mehta P, Rathod KG, Bhalla K, Nanda S. To study the clinical profile of children with pleural effusion at a Tertiary Care Center in North India: A prospective study. *Indian J Child Health*. 2017;438–41.
- Falguera M, Carratalà J, Bielsa S, García-Vidal C, Ruiz-González A, Chica I, et al. Predictive factors, microbiology and outcome of patients with parapneumonic effusion. *Eur Respir J*. 2011;38(5):1173–9.
- Rosenstengel A. Pleural infection-current diagnosis and management. *J Thorac Dis*. 2012;4(2):186.
- Nwagboso CI, Ekeng BE, Etiuma AU, Ochang EA, Eze JN, Echih CP. Microbiological profile and antibiotic resistance pattern of empyema thoracis in Calabar, Nigeria. *Trop Doct*. 2021;51(4):523–6.
- Porcel JM, Gasol A, Bielsa S, Civit C, Light RW, Salud A. Clinical features and survival of lung cancer patients with pleural effusions. *Respirology*. 2015;20(4):654–9.
- Arnold DT, De Fonseka D, Perry S, Morley A, Harvey JE, Medford A, et al. Investigating unilateral pleural effusions: the role of cytology. *Eur Respir J*. 2018;52(5).
- Krishna R, Rudrappa M. Pleural Effusion. 2017;
- Hassan M, Patel S, Sadaka AS, Bedawi EO, Corcoran JP, Porcel JM. Recent insights into the management of pleural infection. *Int J Gen Med*. 2021;3415–29.
- Brims FJH, Lansley SM, Waterer GW, Lee YCG. Empyema thoracis: new insights into an old disease. *Eur Respir Rev*. 2010;19(117):220–8.
- Yang W, Zhang B, Zhang ZM. Infectious pleural effusion status and treatment progress. *J Thorac Dis*. 2017;9(11):4690.
- Walker SP, Morley AJ, Staddon L, De Fonseka D, Arnold DT, Medford ARL, et al. Nonmalignant pleural effusions: a prospective study of 356 consecutive unselected patients. *Chest*. 2017;151(5):1099–105.
- Karkhanis VS, Joshi JM. Pleural effusion: diagnosis, treatment, and management. *Open access Emerg Med OAEM*. 2012;4:31.
- Menzies SM, Rahman NM, Wrightson JM, Davies HE, Shorten R, Gillespie SH, et al. Blood culture bottle culture of pleural fluid in pleural infection. *Thorax*. 2011;thx-2010.
- Davies HE, Davies RJO, Davies CWH. Management of pleural infection in adults: British Thoracic Society pleural disease guideline 2010. *Thorax*. 2010;65(Suppl 2):ii41–53.
- Mohapatra MM, Rajaram M, Mallick A. Clinical, radiological and bacteriological profile of lung abscess-an observational hospital based study. *Open access Maced J Med Sci*. 2018;6(9):1642.
- Lehtomäki AI, Nevalainen RM, Toikkanen VJ, Pohja ES, Nieminen JJ, Laurikka JO, et al. Pleural infection—an indicator of morbidity and increased burden on health care. *Interact Cardiovasc Thorac Surg*. 2020;31(4):513–8.
- Schweigert M, Solymosi N, Dubecz A, Fernández MJ, Stadlhuber RJ, Ofner D, et al. Surgery for parapneumonic pleural empyema—what influence does the rising prevalence of multimorbidity and advanced age has on the current outcome? *Surg*. 2016;14(2):69–75.
- Khan S, Yasin M, Muhammad M, Tareen S, Adeel M, Jan F. Culture and sensitivity patterns of the causative organisms isolated from the patient of Empyema Thoracis. *Pakistan J Chest Med*. 2021;27(2):80–7.
- Dutta V, Khyriem AB, Bora I, Barman H, Lyngdoh WV, Neigrihms S. Bacteriological profile of pleural fluid among the pediatric population in a tertiary care centre—a retrospective analysis. *Int J Heal Sci Res*. 2015;5(9):167–74.
- Porcel JM, Esquerda A, Vives M, Bielsa S. Etiology of pleural effusions: analysis of more than 3,000 consecutive thoracenteses. *Arch Bronconeumol (English Ed)*. 2014;50(5):161–5.
- Wrightson JM, Wray JA, Street TL, Chapman SJ, Crook DWM, Rahman NM. S113 Predictors of bacterial 'load' in pleural infection. *BMJ Publishing Group Ltd*; 2014.
- Bedawi EO, Hassan M, McCracken D, Rahman NM. Pleural infection: a closer look at the etiopathogenesis, microbiology and role of antibiotics. *Expert Rev Respir Med*. 2019;13(4):337–47.
- Psallidas I, Kanellakis NI, Bhatnagar R, Ravindran R, Yousef A, Edey AJ, et al. A pilot feasibility study in establishing the role of ultrasound-guided pleural biopsies in pleural infection (the AUDIO study). *Chest*. 2018;154(4):766–72.
- Maskell NA, Batt S, Hedley EL, Davies CWH, Gillespie SH, Davies RJO. The bacteriology of pleural infection by genetic and standard methods and its mortality significance. *Am J Respir Crit Care Med*. 2006;174(7):817–23.
- Remic. *Référentiel en microbiologie médicale. Remic de la Société française de microbiologie (éd), 7e édition*. 2022. 365–371 p.
- Khodeary A, Mohamed T, Alkhayat K, Sayed S. Bacterial Profile and Antibiotics Susceptibility Pattern of Pleural Effusion Isolates from Sohag University Hospital. *Egypt J Med Microbiol*. 2022;31(3):29–35.
- Teklehyanot F, Legese MH, Desta K. Bacterial profile and their antimicrobial resistance patterns from body fluids at Tikur Anbesa Specialized Hospital, Addis Ababa, Ethiopia. *Biol Med*. 2017;9(05):408.
- Wayne PA. Clinical and Laboratory Standards Institute: Performance standards for antimicrobial susceptibility testing: 20th informational supplement. *CLSI Doc M100-S20*. 2010;
- Insa R, Marín M, Martín A, Martín-Rabadán P, Alcalá L, Cercenado E, et al. Systematic use of universal 16S rRNA gene polymerase chain reaction (PCR) and sequencing for processing pleural effusions improves conventional culture techniques. *Medicine (Baltimore)*. 2012;91(2):103–10.
- Chalmers JD, Singanayagam A, Scally C, Fawzi A, Murray MP, Hill AT.

Risk factors for complicated parapneumonic effusion and empyema on presentation to hospital with community acquired pneumonia. *Thorax*. 2009;

36. Bedawi EO, Hassan M, Rahman NM. Recent developments in the management of pleural infection: a comprehensive review. *Clin Respir J*. 2018;12(8):2309–20.
37. Mohanty S, Kapil A, Das BK. Bacteriology of parapneumonic pleural effusions in an Indian hospital. *Trop Doct*. 2007;37(4):228–9.
38. Dorobăț OM, Moisoiu A, Tălăpan D. Bacteria isolated from pleural fluid and their resistance to antimicrobials. *Pneumologia*. 2006;55(2):47–51.
39. Najah L, Jabri H, El Khattabi W, Afif H. Profil bactériologique des pleurésies purulentes. *Rev Mal Respir*. 2019;36:A151.
40. Vishalakshi B, Hanumanthappa P, Krishna S. A study on aerobic bacteriological profile of sterile body fluids. *Int J Curr Microbiol Appl Sci*. 2016;5(5):120–6.
41. Alelign D, Ameya G, Siraj M. Bacterial pathogens, drug-resistance profile and its associated factors from patients with suspected peritonitis in Southern Ethiopia. *Infect Drug Resist*. 2021;4:107–17.