Judi Clinical Journal | 2025;1(2):126-130
Journal home page: https://judijournal.com

Case Report

Challenging Management of Postoperative Empyema: A Case Report with Literature Review

Hemn H. Kaka Ali[1,2], Abeer K. Abass[3], Ali H. Hasan[1,4], Ahmed H. Ahmed[1], Naser A. Mohammed[5], Twana O. Saeed[1], Marwan N. Hassan[5,6], Yadgar H. Hamakarim[1,7], Deari A. Ismaeil[1,5], Shvan H. Mohammed[6], Hussein M. Hamasalih[1,8], Fahmi H. Kakamad[1,5]*

[1]*Scientific Affairs Department, Smart Health Tower, Madam Mitterrand Street, Sulaymaniyah, Iraq.* [2]*Gastroenterology and Hepatology Department, Sulaimani Teaching Hospital, Zanko Street, Sulaymaniyah, Iraq.* [3]*Unit of Radiology, Department of Surgery, Sulaymaniyah Teaching Hospital, Sulaymaniyah, Iraq.* [4]*Department of Radiology, Sulaimani Directorate of Health, Sulaymaniyah, Iraq.* [5]*College of Medicine, University of Sulaimani, Madam Mitterrand Street, Sulaymaniyah, Iraq.* [6]*Kscien Organization for Scientific Research (Middle East Office), Hamdi Street, Azadi Mall, Sulaymaniyah, Iraq.* [7]*College of Health and Medical Technology, Sulaimani Polytechnic University, Sulaymaniyah, Iraq.* [8]*Department of Nursing, Bright Technical and Vocational Institute, Sulaymaniyah, Iraq.*

**Corresponding author: Dr. Fahmi Hussein Kakamad (Doctors City, Building 11, Apartment 50, Zip code: 46001, Sulaymaniyah, Iraq). fahmi.hussein@univsul.edu.iq*

Received: *Aug 20, 2025* ***Revised:*** *Sep 29, 2025* ***Accepted:*** *Nov 17, 2025* ***First Published:*** *Nov 27, 2025*

Introduction: Pleural empyema is the collection of pus within the pleural cavity, typically arising as a complication of pneumonia, chest trauma, thoracic surgery, or bacterial invasion of the pleural space. This report presents a case of post-surgical pleural empyema caused by *Pseudomonas aeruginosa*, successfully managed with a targeted combination of fosfomycin and colistin, with intrapleural lavage.

Case Presentation: A 37-year-old male developed epigastric pain 12 days after a laparoscopic near-total gastrectomy. A chest computed tomography scan revealed a right-sided pleural empyema. Ultrasound-guided drainage was performed, followed by the intrapleural instillation of alteplase to facilitate breakdown of the loculated empyema. *Pseudomonas aeruginosa* was identified as the causative agent. Based on antimicrobial susceptibility, the patient received intravenous fosfomycin and colistin, along with daily pleural lavage using colistin. Inflammatory markers declined, and the patient showed notable clinical improvement.

Literature Review: A review of five cases of *Pseudomonas aeruginosa* pleural empyema was conducted, including two carbapenem-resistant and one extensively drug-resistant case. The mean patient age was 53.8 years, and 60% (3/5) were female. Four of the five cases (80%) were confirmed using computed tomography, and all patients received antimicrobial therapy, most frequently ceftolozane/tazobactam (60%), ciprofloxacin (60%), and colistin (40%). Surgical management was required in 60% of cases, whereas bacteriophage therapy was utilized in 20%. During follow-up, 60% of patients remained stable, 20% experienced repeated hospital admissions during which antibacterial therapy was withheld, and 20% died due to infectious disease.

Conclusion: Pleural lavage combined with antibiotics such as fosfomycin and colistin may provide an effective treatment for postoperative pleural empyema, with early intervention being critical to prevent clinical deterioration.

Keywords: Pleural empyema, *Pseudomonas aeruginosa*, intrapleural lavage, colistin, antibiotic, antibiotic resistance

How to cite this article: Kaka Ali HH, Abass AK, Hasan AH, Ahmed AH, Mohammed NA, Saeed TO et al. Challenging Management of Postoperative Empyema: A Case Report with Literature Review. Judi Clin. J. 2025;1(2):126-130. https://doi.org/10.70955/JCJ.2025.16

1. Introduction

Pleural empyema is the accumulation of pus within the pleural cavity. Although its pathogenesis is not entirely clear, it typically arises from pneumonia, chest trauma, postoperative complications following thoracic surgery, or bacterial invasion from adjacent infection [1]. Epidemiological data from France report an incidence of approximately 0.78 cases per 10,000 people annually [2]. Mortality is not uncommon, with overall rates around 17%, and most patients require hospitalization [2]. Approximately 25–50% of patients with pneumonia develop a parapneumonic effusion, which may progress to empyema in some cases [3]. The factors contributing to the progression of pneumonia to empyema remain poorly understood [4]. However, pleuritic pain, higher severity scores for community-acquired pneumonia, multilobar involvement on imaging, and elevated inflammatory markers have been associated with an increased risk of progression. In contrast, administration of systemic corticosteroids at the time of admission has been linked to a reduced risk, possibly by decreasing pleural inflammation [5]. The use of corticosteroids in community-acquired pneumonia remains

debated: the Infectious Diseases Society of America recommends them only for septic shock unresponsive to vasopressors, whereas European guidelines suggest their use more broadly in cases of shock [5].

Pseudomonas aeruginosa is a widely distributed Gram-negative bacterium that can be found in various environmental settings and hosts [6]. It can cause various infections in humans, especially affecting the respiratory tract of patients with cystic fibrosis [7]. Its clinical impact is amplified by intrinsic antibiotic resistance, mediated through biofilm formation, antibiotic-modifying enzymes, multiple efflux pumps, and low cell permeability, making infections particularly challenging in immunocompromised or chronically ill patients [6].

This report presents a case of pleural empyema due to *Pseudomonas aeruginosa* approximately two weeks after a laparoscopic near-total gastrectomy, successfully managed with a combination of fosfomycin and colistin alongside intrapleural lavage. This report was prepared in accordance with CaReL guidelines, and all references cited have been carefully assessed for credibility [8, 9].

2. Case Presentation

2.1. Patient Information

A 37-year-old male smoker presented with epigastric pain, low-grade fever, anorexia, and generalized weakness following 12 days after laparoscopic near-total gastrectomy with spleen-preserving D2 lymph node dissection for gastric cancer. The patient had a recent influenza infection three weeks prior to surgery. Other than the gastrectomy, no significant medical or surgical history was reported.

2.2. Clinical Findings

Upon examination, he appeared agitated and fatigued, with a generally ill appearance. Vital signs showed tachycardia (heart rate 105 bpm) and tachypnea (25 breaths per minute), while oxygen saturation and blood pressure remained within normal limits. Chest auscultation revealed diminished breath sounds over the right lower lung.

2.3. Diagnostic Approach

Laboratory investigations revealed markedly elevated inflammatory markers, with a C-reactive protein (CRP) level of 180 mg/L (Normal range: < 3 mg/L) and an erythrocyte sedimentation rate (ESR) of 95 mm/hr (Normal range: < 15 mm/hr). Chest computed tomography (CT) confirmed the presence of a right-sided pleural empyema (Figure 1), while abdominal CT ruled out an anastomotic leak. These findings suggested the empyema likely resulted from postoperative pneumonia progressing to a complicated pleural infection rather than a direct surgical complication.

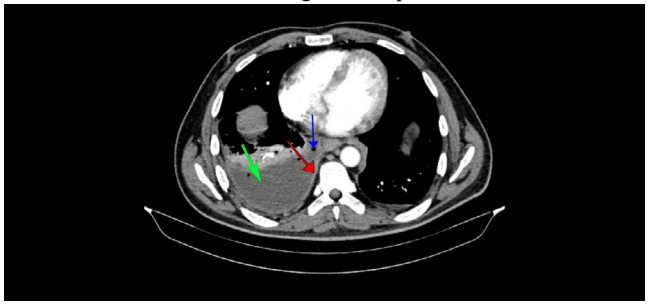

Figure 1. CT demonstrates mild right side pleural effusion (green arrow), small air bubbles inside (blue arrow), thickening & enhancement of parietal & visceral pleura (red arrow), and adjacent right lung atelectatic changes noted.

2.4. Therapeutic Intervention

Ultrasound-guided drainage was performed, and a chest tube was inserted, initially draining 100 cc of pus. The following day, 50 mg of alteplase diluted in 100 cc of normal saline was administered through the tube. After a 4-hour dwell time, drainage increased to 500 cc, indicating effective fibrinolysis and breakdown of loculated empyema. Empirical broad-spectrum antibiotic therapy with meropenem (1 g every 8 hours) was initiated pending culture results, and the patient maintained a regular oral diet.

2.5. Culture Results and Targeted Antimicrobial Therapy

Microbiological analysis of the drained pus, performed using the advanced VITEK-II Compact (bioMérieux) diagnostic system, identified *Pseudomonas aeruginosa* as the causative agent. Antimicrobial susceptibility testing showed that the strain was multidrug-resistant (MDR), with sensitivity limited to colistin, aztreonam, and fosfomycin (Table 1). The patient received intravenous fosfomycin (4 g every 8 hours for 7 days) and colistin (initially 3 million units every 8 hours for 7 days, followed by 1 million units every 8 hours for 12 days). Pleural lavage with colistin was performed every 12 hours for 5 days, once daily for 7 days, and then on alternate days for an additional 7 days to enhance local antibiotic concentrations.

2.6. Monitoring and Outcome

Daily clinical assessments and serial inflammatory marker measurements were performed. Vital signs normalized, CRP returned to normal, and ESR decreased to 40 mm/hr. Follow-up cultures from the chest drain were negative. Given significant clinical improvement, the chest tube was removed, and the patient was discharged in stable condition. He was subsequently referred to an oncology for ongoing management of gastric cancer. At 10 months post-treatment, there was no evidence of recurrence. The patient has completed adjuvant chemotherapy and continues to undergo regular follow-up with upper gastrointestinal endoscopy and chest and abdominal CT scans.

3. Discussion

Empyema has increasingly been recognized as a reservoir for resistant bacteria, largely because many antibiotics penetrate the pleural space at subtherapeutic concentrations, thereby promoting resistance development [10]. Clinically, the disease progresses through three distinct stages—uncomplicated parapneumonic effusion, complicated parapneumonic effusion, and established empyema—which highlight its dynamic pathophysiology and the need for timely intervention [1]. In parallel with this progression, the incidence of MDR and XDR *Pseudomonas aeruginosa* has risen substantially. This trend is driven by the organism's ability to cause severe healthcare-associated infections, its exceptional capacity to accumulate and spread resistance determinants within the host, and the global dissemination of high-risk clones. As a result, infections caused by these strains pose significant clinical challenges and are associated with increased morbidity and mortality due to limited therapeutic options [11]. The severity of empyema and its outcomes are reflected in epidemiologic data. Bobbio et al. studied adults hospitalized with pleural infections in France between 2013 and 2017, identifying 25,512 empyema cases with an annual incidence of 7.15–7.75 per 100,000 inhabitants. Mortality rates varied substantially depending on underlying conditions, reaching 30% in cancer patients, 18% after lung resection, and 11% among patients without these comorbidities [2]. This variability underscores the importance of understanding pathogen behavior in the context of patient-specific risk factors.

Table 1. Antimicrobial susceptibility testing results.

Antimicrobials	Inhibition zone (mm)	Interpretation	Antimicrobials	Inhibition zone (mm)	Interpretation
Cefixime	0	Resistant	Moxifloxacin	0	Resistant
Cefuroxime	0	Resistant	Levofloxacin	0	Resistant
Cefotaxime	0	Resistant	Doxycycline	0	Resistant
Ertapenem	0	Resistant	Minocycline	0	Resistant
Cefpodoxime–clavulanate	0	Resistant	Tigecycline	0	Resistant
Aztreonam	20	Sensitive	Nitrofurantion	0	Resistant
Rifampin	0	Resistant	Streptomycin	0	Resistant
Colistin	19	Sensitive	Azithromycin	0	Resistant
Fosfomycin	24	Sensitive	Clarithromycin	0	Resistant

Among the common pathogens, *Pseudomonas aeruginosa* remains a notable cause of hospital-acquired pneumonia and is frequently detected in airway colonization, especially in previously treated individuals. The development of MDR phenotypes not only complicates therapy but may also alter the organism's virulence characteristics [12]. Its adaptability is further demonstrated by its ability to colonize diverse hospital environments, including soap solutions and saline, facilitating persistent contamination and transmission. Consequently, treatment strategies must be tailored to the organism's susceptibility pattern and the clinical scenario, often relying on agents such as colistin, ceftazidime, meropenem, and amikacin. However, therapeutic success is hindered by multiple resistance mechanisms, ranging from chromosomal mutations to horizontally acquired β-lactamases [13].

A review of five similar cases of empyema illustrates this complexity. The cases involved patients aged 22–77 years, with *Pseudomonas aeruginosa* identified in all isolates. While two isolates were carbapenem-resistant and one was XDR, resistance profiles were not reported for the remaining two. Imaging modalities, most commonly CT, confirmed empyema or associated cavitary lesions. All patients received antimicrobial therapy, with ceftolozane/tazobactam, colistin, and ciprofloxacin being most frequently used. Surgical interventions such as thoracotomy or video-assisted thoracoscopic surgery were required in 60% of patients, while adjunctive measures like bacteriophage therapy were rarely used (20%). Only one patient died, emphasizing both the severity of these infections and the potential for successful outcomes when appropriate therapy is provided (Table 2) [10, 14-17]. In the present case, treatment with intravenous fosfomycin in combination with colistin was guided by the antimicrobial susceptibility profile and resulted in a favorable clinical response. Evidence supports the synergy of this combination, in a study of 87 carbapenem-resistant *Pseudomonas aeruginosa* isolates, the fosfomycin and colistin regimen exhibited synergistic or partially synergistic effects in nearly half of the isolates and significantly reduced colistin MIC values compared with monotherapy [18]. These findings suggest that fosfomycin may enhance colistin's efficacy and therapeutic window. Conversely, when resistance to fosfomycin does occur, it is typically mediated through FosA overexpression or inactivation of the glycerol-3-phosphate transporter responsible for drug uptake [19].

The relevance of this combination is supported by a comparable case involving a 64-year-old patient with chronic post-pleuropneumonectomy empyema caused by carbapenem-resistant *Pseudomonas aeruginosa* [16]. In that case, surgical debridement followed by cefiderocol, fosfomycin, and colistin—along with pleural lavage using colistin—resulted in clinical improvement, highlighting the potential role of both systemic and local therapy. Monitoring inflammatory markers, especially C-reactive protein, further assists in assessing response, as a rapid decline typically correlates with resolution of infection [20], consistent with the trajectory observed in the present case.

Given the rise of resistance, interest has grown in adjunctive and alternative therapeutic approaches. Bacteriophage therapy is particularly notable, as combining phages with antibiotics can produce synergistic antimicrobial effects, a finding supported by multiple in vitro studies [13]. Although limited by narrow host ranges, phages may offer options for otherwise untreatable infections [21]. This was exemplified by Maddocks et al., who treated a 77-year-old patient with ventilator-associated pneumonia and empyema due to *Pseudomonas aeruginosa* using the AB-PA01 phage cocktail after resistance emerged during antibiotic therapy. Intravenous and nebulized administration led to gradual clinical improvement, demonstrating the potential of phage–antibiotic combinations in refractory cases [17].

Further emerging strategies include vaccines and monoclonal antibodies targeting virulence factors such as the type III secretion system. Candidates like IC43, KB001-A, and KBPA-101 are being investigated for preventive and therapeutic roles in high-risk populations [11]. In the current case, such alternatives were not required, as the selected antibiotic regimen successfully controlled the infection without the need for surgical intervention.

A limitation of this study is the unavailability of certain clinical data, including abdominal CT images obtained to exclude an anastomotic leak and specific laboratory values..

4. Conclusion

Pleural lavage combined with antibiotics such as fosfomycin and colistin may provide an effective treatment for postoperative pleural empyema, with early intervention being critical to prevent clinical deterioration.

Table 2. Review of five cases of empyema caused by *Pseudomonas aeruginosa*.

Author, year of publication	Age (years)	Sex	Clinical finding	Diagnosis	Imaging	Antimicrobial susceptibility	Treatment	Outcome
Sousou *et al*. 2024 [14]	61	M	Left-sided chest pain and shortness of breath, worsening dyspnea on exertion.	Influenza A initially, later empyema from *P. aeruginosa.*	CT: large left pleural effusion. US: extensively multiloculated, dense pleural fluid.	Sensitivity: cefepime & ciprofloxacin	Video-assisted thoracoscopic surgery, & left thoracotomy with complete decortication. First given cefepime then ciprofloxacin.	Stable
Parra *et al*. 2022 [15]	22	F	respiratory failure with necrotizing pneumonia	Pleural empyema due to carbapenem-resistant *P. aeruginos*a.	Radiologically compatible with necrotizing pneumonia.	Resistance: ceftolozane/tazobactam & ceftazidime-avibactam.	Intravenous ceftazidime later ceftolozane/tazobactam, then changed to ciprofloxacin & nebulized colistin.	Deceased
Borghesi *et al*. 2021 [16]	64	M	Increased discharge from the pleural drainage.	Chronic left pleural empyema caused by a carbapenem-resistant *P. aeruginosa.*	A CT scan of the thorax was suggestive of interstitial pneumonia.	Resistance: all β-lactams & quinolones. Sensitivity: ceftolozane/tazobactam, gentamicin, amikacin & colistin.	ceftolozane/tazobactam & gentamicin. Surgical debridement procedure, cefiderocol, colistin & Fosfomycin.	Stable
Kufel *et al*. 2020 [10]	45	F	Leukocytosis, respiratory failure, fever, & increased tracheal secretions.	Empyema caused by XDR *P. aeruginosa*.	CT: loculated left & right pleural effusions.	Sensitivity: cefiderocol, but later 2 cefiderocol-resistant morphologies of XDR *P. aeruginosa* were found.	Ceftazidime-avibactam, polymyxin B, & fluconazole, later fluconazole & cefiderocol. Esophageal stent replacement, video-assisted thoracoscopic surgery with left lung thoracotomy & decortication, & esophageal rupture repair with muscle flap placement.	Repeated hospital admissions; antibacterial therapy withheld
Maddocks *et al*. 2019 [17]	77	F	Pleuritic chest pain, respiratory distress, drowsiness & fever, parenchymal cavitation.	Ventilator-associated pneumonia and empyema caused by *P. aeruginosa.*	CT: cavitation, consolidation, empyema, & subcutaneous emphysema. X-ray: right lung field consolidation, & later pneumothorax.	Sensitivity: piperacillin tazobactam, ciprofloxacin, & meropenem. But later resistant to meropenem, imipenem, piperacillin-tazobactam in vitro, & fluoroquinolone.	First meropenem, then gentamicin, & ciprofloxacin later ceftolozane/tazobactam. Bacteriophage therapy: two Myoviridae & two Podoviridae.	Stable

P. aeruginosa: *Pseudomonas aeruginosa,* ***M:*** *Male,* ***F:*** *Female,* ***CT:*** *Computed tomography,* ***US:*** *Ultrasonography,* ***XDR:*** *Extensively drug-resistant.*

Declarations

Conflicts of interest: The authors have no conflicts of interest to disclose.

Ethical approval: Not applicable.

Consent for participation: Not applicable.

Consent for publication: Written informed consent for publication was obtained from the patient.

Funding: The present study received no financial support.

Acknowledgments: None to be declared.

Authors' contributions: HHK, AKA, AHH, FHK, NAM and TOS: Major contributors to the conception of the study, as well as the literature search for related studies, and manuscript writing. AHA, MNH, YHH, DAI, SHM and HMH: Literature review, critical revision of the manuscript, and processing of the figure and tables. All authors have read and approved the final version of the manuscript.

Use of AI: ChatGPT-4.5 was used to assist with language refinement and improve the overall clarity of the manuscript. All content was thoroughly reviewed and approved by the authors, who bear full responsibility for the final version.

Data availability statement: Not applicable.

References

1. Redden MD, Chin TY, van Driel ML. Surgical versus non-surgical management for pleural empyema. Cochrane Database of Systematic Reviews.2017;**3(3)**:CD010651. https://doi.org/10.1002/14651858.cd010651.pub2
2. Bobbio A, Bouam S, Frenkiel J, Zarca K, Fournel L, Canny E et al. Epidemiology and prognostic factors of pleural empyema. Thorax. 2021;**76(11)**:1117-23. https://doi.org/10.1136/thoraxjnl-2020-215267
3. Sahn SA. Diagnosis and management of parapneumonic effusions and empyema. Clinical Infectious Diseases. 2007;**45(11)**:1480-6. https://doi.org/10.1086/522996
4. Elemraid MA, Thomas MF, Blain AP, Rushton SP, Spencer DA, Gennery AR et al. North East of England Pediatric Respiratory Infection Study Group Newcastle upon Tyne, UK. Risk factors for the development of pleural empyema in children. Pediatric pulmonology. 2015;**50(7)**:721-6. https://doi.org/10.1002/ppul.23041
5. Bravo Jover RM, Gil-Guillen VF, Pérez Barba C, Quesada JA, García López M, García Soriano I, et al. Factors Associated with Complicated Parapneumonic Pleural Effusion/Empyema in Patients with Community-Acquired Pneumonia: The EMPIR Study. Journal of Clinical Medicine. 2025;**14(5)**:1739. https://doi.org/10.3390/jcm14051739
6. Krell T, Matilla MA. Pseudomonas aeruginosa. Trends in microbiology. 2024;**32(2)**:216-8. https://doi.org/10.1016/j.tim.2023.11.005
7. Zhang S, Stallforth P. Biofilms and exopolysaccharides in Pseudomonas aeruginosa: pathogenesis, immune evasion, and lung–brain signaling during pneumonia. Signal Transduction and Targeted Therapy. 2024;**9(1)**:204. https://doi.org/10.1038/s41392-024-01902-4
8. Abdullah HO, Abdalla BA, Kakamad FH, Ahmed JO, Baba HO, Hassan MN, et al. Predatory Publishing Lists: A Review on the Ongoing Battle Against Fraudulent Actions. Barw Medical Journal. 2024;**2(3)**:26-30 https://doi.org/10.58742/bmj.v2i2.91
9. Prasad S, Nassar M, Azzam AY, García-Muro-San José F, Jamee M, Sliman RK, et al. CaReL guidelines: A consensus-based guideline on case reports and literature review (CaReL). Barw Medical Journal. 2024;**2(3)**:13-19. https://doi.org/10.58742/bmj.v2i2.89
10. Kufel WD, Steele JM, Riddell SW, Jones Z, Shakeraneh P, Endy TP. Cefiderocol for treatment of an empyema due to extensively drug-resistant Pseudomonas aeruginosa: clinical observations and susceptibility testing considerations. IDCases. 2020;**21**:e00863. https://doi.org/10.1016/j.idcr.2020.e00863
11. Horcajada JP, Montero M, Oliver A, Sorlí L, Luque S, Gómez-Zorrilla S, et al. Epidemiology and treatment of multidrug-resistant and extensively drug-resistant Pseudomonas aeruginosa infections. Clinical microbiology reviews. 2019;**32(4)**:10-128. https://doi.org/10.1128/cmr.00031-19
12. Giamarellos-Bourboulis EJ, Tzepi I, Tsovolou I, Spyridaki A, Tsaganos T, Vaki I, et al. Polychronopoulos V. Impact of multidrug resistance on experimental empyema by Pseudomonas aeruginosa. Respiration. 2011;**82(1)**:46-53. https://doi.org/10.1159/000326893
13. Santamaría-Corral G, Senhaji-Kacha A, Broncano-Lavado A, Esteban J, García-Quintanilla M. Bacteriophage–Antibiotic Combination Therapy against Pseudomonas aeruginosa. Antibiotics. 2023;**12(7)**:1089. https://doi.org/10.3390/antibiotics12071089
14. Sousou J, Karan A, Taylor M, Stachler L, Aung W. AN UNUSUAL CASE OF INFLUENZA A-INDUCED EMPYEMA FROM PSEUDOMONAS AERUGINOSA. CHEST. 2024;**166(4)**:A1387-8. https://doi.org/10.1016/j.chest.2024.06.889
15. Parra AP, Moral LD, Santed MR, Domingo DA, Gutiérrez JD, Torner MG. 4CPS-038 Intrapleural colistin for pleural empyema caused by extensively drug-resistant Pseudomonas aeruginosa: a case report. 2022;**29(Suppl1)**. https://doi.org/10.1136/ejhpharm-2022-eahp.83
16. Borghesi L, Viaggi V, Franzetti M, Montoli M, Mauri C, Moioli G, et al. Successful prolonged cefiderocol treatment of a chronic left pleural empyema caused by Pseudomonas aeruginosa in a patient affected by COVID-19: a case report. Journal of Global Antimicrobial Resistance. 2021;**27**:157-9. https://doi.org/10.1016/j.jgar.2021.09.005
17. Maddocks S, Fabijan AP, Ho J, Lin RC, Ben Zakour NL, Dugan C, et al. Bacteriophage therapy of ventilator-associated pneumonia and empyema caused by Pseudomonas aeruginosa. American journal of respiratory and critical care medicine. 2019;**200(9)**:1179-81. https://doi.org/10.1164/rccm.201904-0839LE
18. Di X, Wang R, Liu B, Zhang X, Ni W, Wang J, et al. In vitro activity of fosfomycin in combination with colistin against clinical isolates of carbapenem-resistant Pseudomas aeruginosa. The Journal of Antibiotics. 2015;**68(9)**:551-5. https://doi.org/10.1038/ja.2015.27
19. Pipitone G, Di Bella S, Maraolo AE, Granata G, Gatti M, Principe L, et al. Intravenous fosfomycin for systemic multidrug-resistant pseudomonas aeruginosa infections. Antibiotics. 2023;**12(12)**:1653. https://doi.org/10.3390/antibiotics12121653
20. Dilber E, Cakir M, Kalyoncu M, Okten A. C-reactive protein: a sensitive marker in the management of treatment response in parapneumonic empyema of children. The Turkish Journal of Pediatrics. 2003;**45(4)**:311-4.
21. Hill C, Mills S, Ross RP. Phages & antibiotic resistance: are the most abundant entities on earth ready for a comeback?. Future Microbiology. 2018;**13(6)**:711-26. https://doi.org/10.2217/fmb-2017-0261