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CASE REPORT Open Access

A case of septic pulmonary embolism caused by *P. aeruginosa* in a hemodialysis patient and review of the literature

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Abstract

Background: Septic pulmonary embolism (SPE) is an uncommon but serious complication resulting from infection of the blood. Gram-positive cocci, including methicillin-susceptible *Staphylococcus aureus* and methicillin-resistant *Staphylococcus aureus*, are the most common causative organisms of SPE. Few case reports have been published on SPE caused by *Pseudomonas aeruginosa* (*P. aeruginosa*), and thus, the consensus treatment of SPE caused by *P. aeruginosa* infections remains undetermined. Management of *P. aeruginosa* infection can be challenging due to its poor prognosis and antimicrobial resistance. Here, we report a case of successful combination antibiotic therapy for SPE associated with infective endocarditis (IE) caused by *P. aeruginosa* in a hemodialysis patient, with a review of the literature.

Case presentation: A 62-year-old man receiving maintenance hemodialysis as treatment for end-stage renal disease due to IgA nephropathy was admitted to our hospital with high fever and chills lasting 10 days. Chest computed tomography revealed multiple nodular shadows, and gram-negative rods were confirmed by blood culture obtained on admission. We suspected SPE and initiated meropenem (MEPM) treatment. *P. aeruginosa* was identified in blood cultures, and transesophageal echocardiography demonstrated vegetation on the tricuspid valve. Therefore, a diagnosis of SPE associated with IE caused by *P. aeruginosa* was made. *P. aeruginosa* isolates showed good susceptibility to MEPM, but no symptomatic improvement was observed. Thus, antibiotics were changed from MEPM to a combination of ceftazidime and tobramycin (TOB). The patient exhibited a favorable response to the combination therapy, although we discontinued TOB on day 23 because of tinnitus symptoms.

Conclusions: We report a rare case of SPE associated with IE caused by *P. aeruginosa* in a hemodialysis patient. Combination antibiotic therapy may be effective in this situation.

Keywords: Hemodialysis, Septic pulmonary embolism, *Pseudomonas aeruginosa*, Infective endocarditis, Combination antibiotic therapy

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Background

Septic pulmonary embolism (SPE) is an uncommon complication in which infected thrombi from a primary infectious site lead to infarctions in the pulmonary vasculature [1]. Very few case reports have been published on SPE caused by *Pseudomonas aeruginosa* (*P. aeruginosa*); therefore, no consensus has been reached as to the treatment of SPE caused by *P. aeruginosa*. We report our rare experience with successful combination antibiotic therapy for SPE associated with infective endocarditis (IE) caused by *P. aeruginosa* in a hemodialysis patient.

Case presentation

A 62-year-old man was admitted to our hospital with a 10-day history of high fever and chills. He developed end-stage renal disease due to IgA nephropathy 16 years ago and started maintenance hemodialysis through a native arteriovenous fistula. He did not take any antibiotics prior to admission. On admission, his body temperature was 37.5 °C, his blood pressure was 108/69 mmHg, his respiratory rate was 12 breaths/min, his SpO_2 was 96% in ambient air, and he presented with tachycardia (120 beats/min). On physical examination, no obvious evidence of an infection site was observed, including the infection of arteriovenous fistula. He experienced no respiratory symptoms, and his breath and heart sounds were normal. Complete blood counts showed a white blood cell count of 25,800/μL with a left shift, hemoglobin of 11.8 g/dL, and a platelet count of 163,000/μL. The results of blood chemistry tests were as follows: aspartate aminotransferase 31 IU/L, alanine aminotransferase 32 IU/L, total protein 6.3 g/dL, albumin 3.6 g/dL, blood urea nitrogen 32.9 mg/dL, and creatinine 9.08 mg/dL. Lactate dehydrogenase was 227 IU/L, and C-reactive protein was 23.27 mg/dL. Laboratory results are summarized in Table 1. Chest X-ray and contrast-enhanced chest computed tomography (CT) revealed multiple bilateral peripheral nodular lesions in both lungs (Fig. 1a). Meropenem (MEPM) (1 g daily) was administered as the initial antibiotic treatment. Later, *P. aeruginosa* was detected in 2 of 4 blood cultures. Clinical symptoms, positive blood culture results, and imaging findings of pulmonary thrombosis suggested the presence of SPE. Transthoracic echocardiography revealed no vegetation, but transesophageal echocardiography demonstrated a mobile vegetation of 8 mm on the tricuspid valve. No obvious findings of congenital heart disease or valvular disease were observed. The diagnosis of SPE associated with IE caused by *P. aeruginosa* was made based on these findings. Although the isolated bacterium exhibited good susceptibility to MEPM, the patient's fever was prolonged and CT findings worsened compared with those on admission (Figs. 1b, 2). Then, we changed MEPM to a combination therapy of ceftazidime (2 g daily) and tobramycin (TOB) (120 mg after each hemodialysis session). After changing antibiotics, his fever and leukocytosis resolved. He experienced tinnitus on day 23 and thus TOB was stopped due to suspicion of adverse effects. After TOB was stopped, his tinnitus resolved and he completed 6 weeks of antibiotic therapy. On day 51, he was discharged from our hospital without any symptoms.

Discussion and conclusions

SPE is an uncommon but serious disease characterized by pulmonary embolism of infected thrombi from a primary infectious site. The diagnostic criteria of SPE have not been established, and diagnosis is generally made

Table 1 Baseline laboratory results of the patient

WBC count	25,800/μL	AST	31 U/L	Cl	100 mEq/L
Neutrophils	88 %	ALT	32 U/L	Ca	10.3 mg/dL
Eosinophils	0 %	LDH	227 U/L	P	5.1 mg/dL
Basophils	1 %	ALP	270 U/L	CRP	23.27 mg/dL
Lymphocytes	3 %	Cholinesterase	199 U/L	Fe	5 μg/dL
Monocytes	8 %	Total bilirubin	0.5 mg/dL	UIBC	195 μg/dL
RBC count	364 × 10^4/μL	Total protein	6.3 g/dL	Ferritin	135.0 ng/mL
Hemoglobin	11.8 g/dL	Albumin	3.6 g/dL	BNP	428.7 pg/mL
Hematocrit	35.9 %	BUN	32.9 mg/dL		
Platelet count	163,000/μL	Creatinine	9.08 mg/dL		
PT	80.9 %	eGFR	5 mL/min/1.73m^2		
APTT	28.3 s	Na	140 mEq/L		
Fibrinogen	533.0 mg/dL	K	4.9 mEq/L		

WBC white blood cell, *RBC* red blood cell, *PT* prothrombin time, *APTT* activated partial thromboplastin time, *AST* aspartate transaminase, *ALT* alanine aminotransferase, *LDH* lactate dehydrogenase, *ALP* alkaline phosphatase, *BUN* blood urea nitrogen, *eGFR* estimated glomerular filtration rate, *CRP* C-reactive protein, *UIBC* unsaturated iron binding capacity, *BNP* brain natriuretic peptide

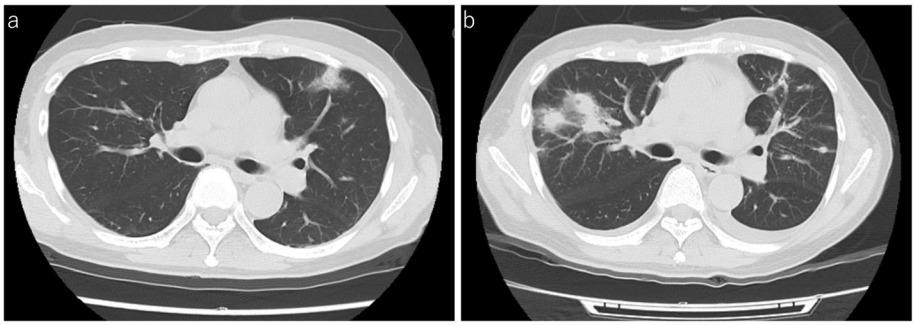

Fig. 1 **a** Chest CT scan on admission shows multiple nodular lesions in both lungs. **b** Repeated chest CT scan 9 days later shows worsening lung nodular lesions

based on the presence of predisposing infectious sites, febrile illness, and lung CT findings [2]. Typical CT findings include multiple peripheral lung nodules with or without cavitations, pleura-abutting wedge-shaped peripheral lesions, a feeding vessel sign, and pleural effusion [3]. In our case, we made the diagnosis of SPE based on fever, blood culture results, multiple peripheral nodules visible on chest CT, and the presence of right-sided IE as the predisposing infectious site. The primary infectious sites of SPE include right-sided IE, pelvic thrombophlebitis, head and neck infections, vascular catheters, implantable devices, and soft tissue infections [2, 4]. The risk factors for SPE include intravenous drug use, catheter insertion, and diabetes mellitus [5]. In addition, in the single-center retrospective analysis of 40 SPE patients, up to 25% of patients (10 patients) were hemodialysis patients [4]; thus, hemodialysis may be a risk factor for SPE. We should therefore consider SPE when we examine hemodialysis patients with fever and bacteremia.

The most common causative organisms of SPE are methicillin-susceptible *Staphylococcus aureus* (32%), methicillin-resistant *Staphylococcus aureus* (18%), Fusobacteria (7%), Klebsiella (7%), Candida (4%), and *Streptococcus viridans* (3%) [6]. SPE caused by *P. aeruginosa*, which is the pathogenic organism in our case, has only been rarely reported. To the best of our knowledge, only eight reports of SPE caused by *P. aeruginosa* exist in the literature. Table 2 lists the clinical features of six reports including our case, except for two reports that provided no detailed descriptions. Patients may be in their 20s to their 60s, whereas no elderly patients have been reported. Moreover, 2 of 6 patients (33%) were hemodialysis patients. The primary infectious site varied among patients, and no patient was affected with IE except for our case. All patients were treated with antimicrobial agents, but whether patients received monotherapy or combination therapy was unclear. Three patients required surgical management, and two patients died during the course of treatment. Based on these findings, SPE caused by

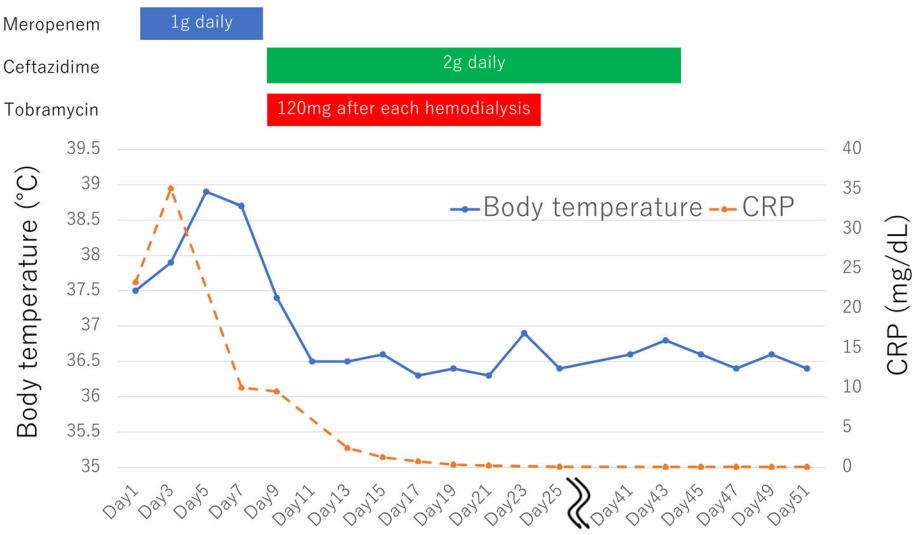

Fig. 2 Clinical course of the patient

Table 2 Clinical features of 6 reports of septic pulmonary embolism caused by *P. aeruginosa*

	Age/sex	Maintenance hemodialysis	Primary source of infection	Treatment	Outcome
Present case	62/male	+	Infective endocarditis	MEPM → CAZ + TOB	Survived
[7]	Unknown	-	Pneumonia	Tube thoracostomy	Died
[8]	50s/female	+	Arteriovenous fistula infection	MEPM Shunt aneurysmectomy	Survived
[9]	50/male	-	Central venous catheter infection	IPM → CAZ → CPFX	Survived
[10]	25/unknown	-	Necrotizing fasciitis of the upper limb	Antibiotics (details unknown)	Survived
[11]	52/female	-	Arterial thrombi	Thrombectomy antibiotics (details unknown)	Died

MEPM meropenem, *CAZ* ceftazidime, *TOB* tobramycin, *IPM* imipenem, *CPFX* ciprofloxacin

P. aeruginosa could be an uncommon but life-threatening disorder.

The mainstay of SPE treatment is the use of empiric broad-spectrum antibiotics for 4–6 weeks and the approach taken for the primary site of infection [4, 12]. We, therefore, devised a treatment plan based on IE treatment. For IE treatment, in addition to antibiotics, surgical intervention is indicated in cases of valvular dysfunction that result in heart failure, new heart block, aortic root or annular abscess, penetrating complications, persistent bacteremia, fungemia or infection with some other resistant organism, persistent emboli, enlargement of vegetation despite appropriate antibiotic treatment, or mobile vegetations > 1 cm for left-sided and 2 cm for right-sided IE [13]. On the contrary, some reports recommend early valve replacement surgery in cases of *P. aeruginosa*-induced IE [14]. *Pseudomonas aeruginosa* infections are often difficult to eradicate because this organism gradually develops antibiotic resistance depending on the duration of therapy. Relapses after a seemingly successful treatment are not uncommon [15]. In addition, it is well known that there is a discrepancy between the in vitro and in vivo antibiotic susceptibilities of *P. aeruginosa*, although the mechanism of this phenomenon remains to be clarified [16]. Some cases, including ours, are refractory to antibiotic therapy despite the evidence of in vitro drug susceptibility.

In contrast, some reports recommend using combination antibiotic therapy, typically with antipseudomonal β-lactams and an aminoglycoside, for *P. aeruginosa*-induced IE to prevent acquisition of drug resistance [17]. In our case, first line monotherapy failed to control the bacteremia; however, after switching to combination therapy, the patient exhibited a good response to the treatment without the need for surgical intervention. According to a study, hemodialysis patients undergoing cardiac surgery had high perioperative and medium-term mortality because of valve disease, poor left ventricular function, and other underlying conditions [18]. Therefore, combination antibiotic therapy may have a significant benefit in avoiding high-risk surgical interventions in hemodialysis patients.

SPE is a potentially fatal disease, with a reported mortality rate of 10%–20% [4, 6]. SPE with IE caused by *P. aeruginosa* is more likely to have poor outcomes because IE due to *P. aeruginosa* has a very high mortality rate of 30%–60% [19–21]. In the analysis of IE caused by non-HACEK (species other than *Haemophilus*, *Actinobacillus actinomycetemcomitans*, *Cardiobacterium hominis*, *Eikenella corrodens*, or *Kingella*) gram-negative bacilli, the mortality of IE due to *P. aeruginosa* was high (36%) despite high rates of cardiac surgery (55%) [22]. Therefore, IE due to *P. aeruginosa* requires prompt and effective treatment. Our case indicates that combination antibiotic therapy may be a preferable choice for the initial treatment of SPE associated with IE caused by *P. aeruginosa*.

In conclusion, we experienced a rare case of SPE associated with IE caused by *P. aeruginosa* in a hemodialysis patient. The patient was successfully treated with the combination of antipseudomonal β-lactams and an aminoglycoside and avoided surgical intervention. SPE caused by *P. aeruginosa* is an uncommon but serious disorder, and thus early, appropriate treatment is important. Combination antibiotic therapy with antipseudomonal β-lactams and an aminoglycoside may be effective in the treatment of SPE associated with IE caused by *P. aeruginosa*, particularly in hemodialysis patients. Further studies are required to examine the effectiveness of this therapy with a greater number of patients.

Abbreviations

CT: Computed tomography; IE: Infective endocarditis; MEPM: Meropenem; *P. aeruginosa*: *Pseudomonas aeruginosa*; SPE: Septic pulmonary embolism; TOB: Tobramycin

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Authors' contributions
HS designed this study and wrote the initial draft. HS, MT, YT, MT, KM, HS, SN, KT, SI, MI, and HT participated in the discussion and treatment of the patient. MT reviewed and revised the manuscript. All authors read and approved the manuscript and agree with the submission to this journal.

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Ethics approval and consent to participate
This report was written in compliance with the Declaration of Helsinki. For this type of case report, ethics approval is not required.

Consent for publication
Written informed consent was obtained from the patient for the publication of this case report.

Competing interests
The authors declare that they have no competing interests.

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