Journal of Bacteriology and Mycology

Open Access

Austin Publishing Group

Case Report

Blood Stream Infection Caused by Achromobacter Xylosoxidans: Case Report and Review of Literature

Ucciferri C[1,2], Caiazzo L[1], Pontolillo M[1], Vignale F[1], Vecchiet J[1] and Falasca K[1]*

[1]Clinic of Infectious Diseases, "G. D'Annunzio" University Chieti-Pescara, Italy

[2]Department of Medicine and Health Sciences, University of Molise, Italy

***Corresponding author:** Katia Falasca, Department of Medicine and Science of Aging, "G. D'Annunzio" University Chieti-Pescara, Clinic of Infectious Diseases, Via dei Vestini, 66100 Chieti, Italy

Received: March 16, 2021; **Accepted:** April 09, 2021; **Published:** April 16, 2021

Abstract

Achromobacter xylosoxidans also known as *Alcaligenes xylosoxidans* is a Gram-negative bacillus found in water and soil. It is an uncommon cause of infection in immunocompetent and immunocompromised patients. This report describes a 47-year-old female diagnosed with common variable immunodeficiency with *Achromobacter xylosoxidans* positive blood cultures and acquired resistance to piperacillin/tazobactam during treatment. This bacterium can cause pathologies with high mortality, due to its ability to create biofilms and its particular pattern of susceptibility to antibiotics. Choosing the right antibiotic is critical because they are highly resistant to antibiotics. Due to the presence of few antibiotics with bactericidal activity, the risk of empirical treatment failure is high and therefore a correct understanding of this rare but fatal disease is important to obtain the best chance of success. For this reason we finally carried out a literature review.

Keywords: *Achromobacter* spp; Antibiotic resistance; Bacteremias; Common variable; Alcaligenes, immunodeficiency; Biofilm; Vascular catheter

Introduction

Achromobacter xylosoxidans ss xylosoxidans (formerly *Alcaligenes xylosoxidans ss xylosoxidans*) is an aerobic, catalase and oxidase positive, non-fermenting gram-negative peritrichous rod; it is found usually in aqueous environments but it is still a human host, occasionally present in the skin and gastrointestinal tract [1]. *A. xylosoxidans* is considered an opportunistic pathogen, causing infection in immunocompromised hosts [1].

Its pathological role has well defined in literature, among dialysis patients, either in hemodialysis or in peritoneal dyalisis [2-4].

While it has been adequately outlined, until now, that *A. xylosoxidans* can cause nosocomial catheter-related bloodstream infection and bacteremias (outbreak or single cases), as far as we know few reports exist that describe catheter-related bloodstream infection neither in dialysis nor in oncologic patients [5].

We describe a clinical case of a patient, afflicted by common variable immunodeficiency, ulcerative colitis and coeliac disease, with a catheter-related blood stream infection sustained by *A. xylosoxidans* and review another cases in literature.

Case Presentation

A 47-year-old woman was admitted to our Infectious diseases ward due to a high-grade fever, chills and weakness lasting for six days. This young woman has suffered from recurring episodes of low respiratory and gastrointestinal tract infections since her childhood. At 27 years of age she was diagnosed with Common variable immunodeficiency. She had total Ig level below 100 mg/dl and a very low level of B lymphocyte, so, started a treatment with a cycle of iv Immunoglobulin every 21 days. During her adulthood, she was diagnosed with Ulcerative colitis and Coeliac disease, that lead her to important malabsorption and weight loss. Given the fact that, no matter that medication, she had been progressing to lose weight and report gastrointestinal symptoms, in February 2014, the Medical equipe she was in charge to decided to propose her the implantation of a Groshing, a vascular catheter, for total parenteral nutrition and albumin infusion. At the end of 2014 she had been hospitalized twice, first for an episode of candidaemia and then for a bacteremia from *S. capitis*. In 2015, a third hospital stay, due to a new Bloodstream Infection (BSI), lead to the substitution of the vascular catheter with a new one: always a Groshong. The patient had been assisted in home care regimen, with a daily visit from a professional nurse that took care of the central venous access, disinfecting it before every use. However, she occasionally needed an hospital admission, to treat and cure episodes of gastrointestinal infection. On 2017 October 25th, she was admitted to our Infectious Disease ward for a sudden appearance of high grade fever and shivering. She noticed that the elevation of the body temperature was related to the use of the Groshong catheter. At the admission, her general conditions were good. She weighted 44 kg. Blood pressure was 90/60 mmHg, heart rate was 120/min, body temperature was 39°C. Laboratory findings on admissions are shown in Table 1. The Chest x-ray was normal. First of all, peripheral and Central Venous Catheters (CVC) blood cultures were performed, then we started an empiric antimicrobial therapy with Piperacillin/tazobactam. On the third day of hospital stay, we observed a new rise of body temperature related to the use of the Groshong catheter. We took once again peripheral and CVC blood cultures. On the seventh day of admission, we performed an echocardiography that was completely normal and ruled out vegetations either of the valve or of the Groshong. *A. xylosoxidans* was isolated from every single culture performed both from peripheral vein and Groshong catheter. The first series of blood cultures taken showed a bacteremia from *A. xylosoxidans* sensible to Piperacillin/tazobactam (Table 2), so we continued to treat her with Piperacillin/tazobactam. However, she presented again a raise in body temperature at day 10th of hospital

Citation: Ucciferri C, Caiazzo L, Pontolillo M, Vignale F, Vecchiet J and Falasca K. Blood Stream Infection Caused by Achromobacter Xylosoxidans: Case Report and Review of Literature. J Bacteriol Mycol. 2021; 8(2): 1169.

Table 1: Laboratory results at the Hospital admission.

Parameter	Patient 's value	Reference range
Haemoglobin	12.2 g/dL	13.0-16.0
White blood cells	3.810 cells/uL	4.000-10.000
Neutrophils	2.570 cells/uL	2.100-7.100
Lymphocytes	1.140 cells/uL	1.100-3.000
Platelets	93.000/mmc	150.000-450.000
INR	1.16	0.950-1.150
C-reactive Protein	14.70 mg/dL	0.00-0.50
Procalcitonin	21.80 ng/ml	0.00-0.50

stay and in the meantime the cultures taken on the 3rd day of admission exhibited a change in bacterial sensitivity (Table 2). While the first blood cultures showed *A.xylosoxidans* sensible to Piperacillin/tazobactam, the second series of cultures revealed *A.xylosoxidans* resistant to Piperacillin/tazobactam. It seemed that the bacteria have developed resistance during the antibiotic treatment. So, we performed a new series of blood cultures and change the antimicrobial, shifting to Meropenem 3g/day. Even though our patient did not improve so much, continuing to present sudden episodes of malaise. We decided to perform again a Transthoracic echocardiography. The exam showed an endocarditis of the vascular catheter, reinforcing the urgent need to remove it. A regimen of enoxaparin 0.4UI twice daily was added, with resolution of the episodes of malaise reported by the patient. Once again, all the blood cultures showed *A.xylosoxidans* strain resistant to Piperacillin/tazobactam. Eventually we continued the antimicrobial until the transfer of the patient to the Hospital in which she substituted the catheter with a new one.

To conduct the review of literature we search PubMed using the following lists of terms: "bacteremia AND xylodoxidans", "catheter AND xylodoxidans", catheter AND achromobacter xylodoxidans bacteremia", "intravascular catheter AND xylodoxidans bacteremia", "central venous catheter AND achromobacter xylodoxidans bacteremia", "endocarditis AND xylodoxidans", "common variable immunodeficiency AND xylodoxidans", "groshong catheter AND xylodoxidans".

We included all the articles fully written in english reporting: bacteremia with or without a secondary localization of infection, endocarditis and rare cases of localized non-bacteremic infection. We decided to focalize only on adult non cystic-fibrosis patients, therefore we excluded papers in cystic-fibrosis (Table 3). Also we exclude studies reporting only neonatal or infant. We included single case reports and review of literature.

Discussion

A. xylosoxidans is a very uncommon human pathogen. As well described in literature, infection from these bacteria are commonly seen in immunosuppressed patients [6-8].

We have considered 367 events reported in literature from 1996 to 2019. Within these cases, we report 243 cases (66.21%) with favorable outcome and 79 (21.52%) deaths. There were 45 cases with unknown outcome.

232 cases were related to a nosocomial infection, emphasizing that *A. xylodoxidans* is an opportunistic pathogen that rarely causes community diseases [4,9,10].

On the other hand, Aisenberg pointed out a conspicuously low frequency of nosocomial infections caused by *A. xylodoxidans* [7]. Also Shie et al, in their series of clinical bacteremias from *A. xylodoxidans* in Taiwan, exhibited how more than a quarter of cases were community acquired [8].

The clinical syndromes are mainly represented by bacteriemia (36.2%); followed by vascular catheter infection (25%), pneumonia (11.7%), endocarditis (6.8%), UTI (2.4%), SSTI (1.9%) (Table 4).

We have observed that 99 patient had a venous catheter. This is a risk factor especially for immunosuppressed people (who often have these devices to infuse chemotherapy or nutrition). Also, on these devices *A.xyodosidans* easily creates biofilms. Associated clinical syndromes can be simple catheter infections, but also endocarditis. The associated symptoms are generally subtle and nuanced, with intermittent and long lasting fever. In his work, Duggan identified, for 26 patients, contaminated solution or hospital equipment as the source of infection [11]. A particular cluster of infections resides in patients on hemodialysis or in peritoneal dialysis [2-4]. A series of report show that *A. xylosoxidans* could be an opportunistic pathogen in dialysis setting, colonizing fluids (didecyldimethylammonium chloride, saline, chlorhexidine and deionized water in hemodialysis systems) and health care workers' hands [11,12].

Furthermore, in an outbreak in a hemodialysis unit, Tena

Table 2: Blood cultures taken at the admission and on 3rd day of admission, both by peripheral and central vascular catheter.

Day 0, before antibiotic initiation		Day 3, during empirical antibiotic therapy	
Antibiotic	***A.xylosoxidans***		
Amoxicillin/clavulanic acid	I 8.000	Amoxicillin/clavulanic acid	
Piperacillin/tazobactam	S <= 4 mg/L	Piperacillin/tazobactam	R >= 64.000
Imipenem	S 1.000	Imipenem	S 1.000
Meropenem	S <= 0.25 mg/L	Meropenem	S <= 0.25 mg/L
Cefotaxime	R >= 32.000	Cefotaxime	R >= 32.000
Ceftazidime	S 2	Ceftazidime	S 4
Gentamicin	R >= 8.000	Gentamicin	R >= 8.000
Amikacina	R >= 32.000	Amikacin	R >= 32.000
Ciprofloxacin	R >= 2.000	Ciprofloxacin	R >= 2.000

Table 3: Articles included in the review and number of cases.

Author/Publication	Year of publication	Cases	Cured	Dead	Unknown Outcome
Lofgren et al.	1981	1	0	1	0
Duggan et al.	1996	77	54	23	0
Martino et al.	1996	1	1		
Knippschild et al.	1996	11	11	0	0
Manfredi et al.	1997	7	7	0	0
Wetkamp et al.	2000	1	1	0	0
Gomez-cerezo et al.	2003	54	46	8	0
Tsay RW et al.	2004	12	10	2	0
Shie et al.	2004	40	21	19	0
Aisenberg et al.	2004	46	39	7	0
Ahn et al.	2005	1	1	0	0
Tena et al.	2005	4	4	0	0
Yilmaz et al.	2006	1	1	0	0
Siebor et al.	2007	12	0	0	12
Nanuashvili et al.	2007	1	1	0	0
Van Hals et al.	2008	1	1	0	0
Moon J. Kim et al.	2008	12	12	0	0
Malek-Marin et al.	2009	1	1	0	0
Teng et al.	2009	1	1	0	0
Ahmed et al.	2009	1	0	1	0
Storey et al.	2010	1	0	1	0
Derber et al.	2011	1	1	0	0
Turgutalp et al.	2011	1	0	1	0
Beherens-Muller et al.	2012	9	9	0	0
Tokuyasu et al.	2012	11	4	7	0
Sawant et al.	2013	1	1	0	0
Lee et al.	2014	1	0	1	0
Rafael et al.	2014	1	1	0	0
Dai et al.	2015	1	0	1	0
Tugcu et al.	2015	1	1	0	0
Patel et al.	2015	1	0	1	0
Raghuraman et al.	2015	1	0	1	0
Liu et al.	2016	15	10	5	0
Kumar et al.	2017	1	0	0	1
Al jasser et al.	2017	1	0	1	0
Rodrigues et al.	2017	1	1	0	0
Donderski et al.	2018	1	1	0	0
Jananthanan et al.	2019	1	1	0	0
Xiaoxia et al. 2019	2019	32	0		32
Total		367	243	79	45

characterized specifically the source of infection, isolating the causative pathogen in an atomizer containing diluted 2.5% chlorhexidine [9].

In our review the most frequent underlying conditions are neoplasms, that are present in almost half of cases (46.8%); of which 38.5% solid tumors and 61.5% hematological malignancies) (Table 5).

Duggan et al. too, reported as the most frequent underlying condition malignancies (23%), solid or hematologic, followed by cardiovascular diseases (16%), renal failure (6%) and diabetes (3%)

[13]. These data has been confirmed in subsequent studies, especially reinforcing the major role of Neoplasms as risk factor [7,8,10,13-24].

Even if, in our records, other conditions have been described as predisposing to infection by *A. xylodoxidans*, like diabetes (12.2%), CV disease (15.5%); neutropenia (14.1%), chemotherapy (4.3%); high dose steroids therapy (6.2%), HIV (3.5%), renal failure (9.5%), COPD (5.1%); liver cirrhosis (2.4%), ours is the first report of BSI in a patient with common variable immunodeficiency . In our scenario, the patient had not been admitted to hospital during the previous three months, but a professional nurse, who provided the management of the Groshong catheter, assisted her in a daily home care regimen. Therefore, we cannot be certain about the community origin of the infection.

On the contrary, the catheter infection has been indirectly proved by the sudden comparison of fever with every use of the Groshong and by the positivity of all the blood cultures performed, from either the catheter or peripheral vein. We can suppose that the aqueous environment and the glucose contained in the nutrient solution facilitated infections with *A. xylosoxidans*. Another element that confirmed the infection of the catheter was the presence of the endocarditis. In literature, the infective endocarditis sustained by *A.xylosoxidans* are quite rare as it is the demonstration of the vegetations directly on the Groshong catheter [3,13,20,25-32].

A particular element of interest consists in the antimicrobial susceptibility pattern. In works collected, *A.xylosoxidans* is often resistant to aminoglycosides (231 cases). Only Weitkamp et al. in 1999 reports that all isolates were susceptible to amikacin and tobramycin [16].

Regardless of the type of molecule, quinolones exhibit a variable sensitivity model. This uniform resistance observed among aminoglycosides is due to an effux pumps33 and fluoroquinolone seems to be secondary to alteration of the DNA gyrase or defective transport of the agents through the cell envelope [34]. *A.xylodoxidans*, is frequently resistant to cephalosporins, with exception for cefriaxone which is effective in most cases. Among beta-lactams, Piperacillin/tazobactam is the most active against *A.xylodoxidans*, while carbapenems are always effective.

In our case, the first series of blood cultures (Table 2), taken at hospitalization, demonstrates a pathogen sensitive to piperacillin/tazobactam (the empirical treatment started at his hospitalization), while the culture was repeated on day 3 of hospitalization. hospital shows resistance to piperacillin/tazobactam. In literature, Sawant et al. showed a shift in the sensitivity pattern toward piperacillin/tazobactam [32]. The rapid switch of sensitivity in our case and the data from Sawant, suggest that the *A.xylodoxidans* has the ability to quickly render piperacillin/tazobactam ineffective, making the choice of this therapeutic option a choice at risk of therapeutic failure. Also in this case *A.xylodoxidans*, caused endocarditis from biofilm on the right ventricular pacemaker lead.

As outlined in a recent review by the group of Didelot, the acquisition of a resistance profile within the host is not uncommon for bacterial pathogens, and several mechanisms have been listed to mediate this phenomenon, most notably horizontal gene transfer, hitchhiking, heteroresistance and selective sweep [35].

Table 4: Clinical syndromes.

Clinical Syndrome	Number of cases
Bacteremia	133
Catheter-related bacteremia	92
Endocarditis	25
Pneumonia	43
UTI	9
SSTI	7
Meningitis	4
Surgical wound infection	5
Septic arhritis	3
GI/BI tract infection	7
Empyema	1
Renal stones	1
Sinusitis	1
Other	4
Unknown	10

Table 5: Most common comorbidities reported.

Comorbid condition	Number of cases
Solid tumor	66
Haematologic malignancies	105
Major surgery	23
Diabetes	45
HIV	13
CKD/ESRD	35
Intravascular catheter	99
COPD	19
Cardiovascular disease	57
Neutropenia	52
High dose steroids	23
Chemotherapy	16
Liver Cirrhosis	9

Abbreviations: AUC: Area Under the Curve; LS: Least Squares; NE: Not Estimable

A.xylosoxidans in particular, shows genomic and phenotypic features that make it a reservoir for transferable elements, like plasmids and integrons, carrying antimicrobial resistance-associated genes, as described in the paper by Traglia et al. [36].

The resistance to Piperacillin/tazobactam has been rarely reported to date; browsing literature, we have found a small percentage of resistance reported in the case series of Shie et al. [8].

Probably the presence of cultures with different antibiotic resistance profiles is due to the presence of biofilm in the catheter. In medical device-related infections, the subsequent failure of antimicrobial therapy regularly requires the removal of the colonized biomaterial, leading to substantial morbidity and mortality. Antimicrobial concentrations sufficient to destroy planktonic organisms are generally inadequate to destroy biofilm organisms,

especially those deep within the biofilm, potentially selecting for resistant subpopulations [37]. Biofilm physiology contributes to tolerance to antimicrobial agent, so biofilm bacteria are physiologically distinct from planktonic bacteria, expressing specific protective factor, such as multidrug efflux pumps and stress response regulation [38]. *A. xylosoxidans* has been shown to form robust biofilms both *in vivo* and *in vitro*, improving the intrinsic resistance to biofilm cell [32,39].

Conclusion

Our review show that *A. xylosoxidans* is a troublesome human pathogen causing nosocomial or community related, hard to treat, infection in immunocompromise patient. The most frequent underlying conditions are represented by malignancies, immunodepression, or the presence of vascular catheters. Due to the high mortality of pathologies caused by *A. xylosoxidans* and the presence of few antibiotics with bactericidal activity, the risk of treatment failure is high (especially in empirical therapy). Furthermore, the particularity of this germ and its ability to create biofilms can render antibiotic therapy ineffective, requiring the mechanical removal of the source of infection to be considered.

Acknowledgment

We are in debt to Dr. A. Gambi and Dr A. Occhionero for helping us.

ICMJE Statement: CL and CU contributed to the writing the manuscript; MP and FV was responsible for the organization and coordination of the trial. JV and FK contributed to the management and analysis of data.

All authors contributed to the writing of the final manuscript.

References

1. Spear JB, Fuhrer J, Kirby BD. Achromobacter xylosoxidans (Alcaligenes xylosoxidans subsp. xylosoxidans) bacteremia associated with a well-water source: case report and review of the literature. J Clin Microbiol. 1988; 26: 598-599.
2. Gomez-Cerezo J, Suarez I, Rios JJ, Pena P, de Miguel MJG, de Jose M, et al. Achromobacter xylosoxidans bacteremia: a 10-year analysis of 54 cases. Eur J Clin Microbiol Infect Dis. 2003; 22: 360-363.
3. Ahmed MS, Nistal C, Jayan R, Kuduvalli M, Anijeet HK. Achromobacter xylosoxidans, an emerging pathogen in catheter-related infection in dialysis population causing prosthetic valve endocarditis: a case report and review of literature. Clin Nephrol. 2009; 71: 350-354.
4. Turgutalp K, Kiykim A, Ersoz G, Kaya A. Fatal catheter-related bacteremia due to Alcaligenes (Achromobacter) xylosoxidans in a hemodialysis patient. Int Urol Nephrol. 2012; 44: 1281-1283.
5. Perez Barragan E, Sandino Perez J, Corbella L, Orellana MA, Fernandez-Ruiz M. Achromobacter xylosoxidans bacteremia: clinical and microbiological features in a 10-year case series. Rev Esp Quimioter. 2018; 31: 268-273.
6. Kish MA, Buggy BP, Forbes BA. Bacteremia caused by Achromobacter species in an immunocompromised host. J Clin Microbiol. 1984; 19: 947-948.
7. Aisenberg G, Rolston KV, Safdar A. Bacteremia caused by Achromobacter and Alcaligenes species in 46 patients with cancer (1989-2003). Cancer. 2004; 101: 2134-2140.
8. Shie SS, Huang CT, Leu HS. Characteristics of Achromobacter xylosoxidans bacteremia in northern Taiwan. J Microbiol Immunol Infect. 2005; 38: 277-282.
9. Tena D, Carranza R, Barbera JR, Valdezate S, Garrancho JM, Arranz M, et al. Outbreak of long-term intravascular catheter-related bacteremia due to Achromobacter xylosoxidans subspecies xylosoxidans in a hemodialysis unit. Eur J Clin Microbiol Infect Dis. 2005; 24: 727-732.
10. Palacios-Gomez ME, Martin-Gomez A, Garcia-Marcos S. Achromobacter xylosoxidans in two haemodialysis patients. Nefrologia. 2014; 34: 538-539.
11. Siebor E, Llanes C, Lafon I, Ogier-Desserrey A, Duez JM, Pechinot A, et al. Presumed pseudobacteremia outbreak resulting from contamination of proportional disinfectant dispenser. Eur J Clin Microbiol Infect Dis. 2007; 26: 195-198.
12. Gahrn-Hansen B, Alstrup P, Dessau R, Fuursted K, Knudsen A, Olsen H, et al. Outbreak of infection with Achromobacter xylosoxidans from contaminated intravascular pressure transducers. J Hosp Infect. 1988; 12: 1-6.
13. Duggan JM, Goldstein SJ, Chenoweth CE, Kauffman CA, Bradley SF. Achromobacter xylosoxidans bacteremia: report of four cases and review of the literature. Clin Infect Dis. 1996; 23: 569-576.
14. Martino R, Martinez C, Pericas R, Salazar R, Sola C, Brunet S, et al. Bacteremia due to glucose non-fermenting gram-negative bacilli in patients with hematological neoplasias and solid tumors. Eur J Clin Microbiol Infect Dis. 1996; 15: 610-615.
15. Knippschild M, Schmid EN, Uppenkamp M, König E, Meusers P, Brittinger G, et al. Infection by Alcaligenes xylosoxidans subsp. xylosoxidans in neutropenic patients. Oncology. 1996; 53: 258-262.
16. Weitkamp JH, Tang YW, Haas DW, Midha NK, Crowe JE. Recurrent Achromobacter xylosoxidans bacteremia associated with persistent lymph node infection in a patient with hyper-immunoglobulin M syndrome. Clin Infect Dis. 2000; 31: 1183-1187.
17. Tsay RW, Lin LC, Chiou CS, et al. Alcaligenes xylosoxidans bacteremia: clinical features and microbiological characteristics of isolates. J Microbiol Immunol Infect. 2005; 38: 194-199.
18. Yilmaz G, Aydin K, Koksal I, Caylan R, Akcay K, Arslan M. Post-ERCP bacteremia caused by Alcaligenes xylosoxidans in a patient with pancreas cancer. Ann Clin Microbiol Antimicrob. 2006; 5: 19.
19. MJ Kim EB, E Lehnkering, RM Donlan, L Mascola. Alcaligenes xylosoxidans Bloodstream Infections in Outpatient Oncology Office. In. Emerg Infect Dis. 2008; 14: 1046-1052.
20. Tokuyasu H, Fukushima T, Nakazaki H, Shimizu E. Infective endocarditis caused by Achromobacter xylosoxidans: a case report and review of the literature. Intern Med. 2012; 51: 1133-1138.
21. Dai J, Huen AO, Kestenbaum LA, Sarezky MD, Coughlin CC, Yan AC. Achromobacter xylosoxidans Bacteremia and Cellulitis: A Report of a Case. Pediatr Dermatol. 2015; 32: e186-187.
22. Tugcu D, Turel O, Aydogan G, Akcay A, Salcioglu Z, Akici F, et al. Successful treatment of multiresistant Achromobacter xylosoxidans bacteremia in a child with acute myeloid leukemia. Ann Saudi Med. 2015; 35: 168-169.
23. Raghuraman K, Ahmed NH, Baruah FK, Grover RK. Achromobacter Xylosoxidans Bloodstream Infection in Elderly Patient with Hepatocellular Carcinoma: Case Report and Review of Literature. J Lab Physicians. 2015; 7: 124-127.
24. Al-Jasser AM, Al-Anazi KA. Complicated septic shock caused by Achromobacter xylosoxidans bacteremia in a patient with acute lymphoblastic leukaemia. Libyan J Med. 2007; 2: 218-219.
25. Rodrigues CG, Rays J, Kanegae MY. Native-valve endocarditis caused by Achromobacter xylosoxidans: a case report and review of literature. Autops Case Rep. 2017; 7: 50-55.
26. van Hal S, Stark D, Marriott D, Harkness J. Achromobacter xylosoxidans subsp. xylosoxidans prosthetic aortic valve infective endocarditis and aortic root abscesses. J Med Microbiol. 2008; 57: 525-527.
27. Ahn Y, Kim NH, Shin DH. Pacemaker lead endocarditis caused by Achromobacter xylosoxidans. J Korean Med Sci. 2004; 19: 291-293.
28. Derber C, Elam K, Forbes BA, Bearman G. Achromobacter species endocarditis: A case report and literature review. Can J Infect Dis Med

Microbiol. 2011; 22: e17-e20.

29. Storey A, Wilson A, McWilliams E. Native valve infective endocarditis due to Achromobacter xylosoxidans in an apparently immunocompetent individual. BMJ Case Rep. 2010; 2010.

30. Lofgren RP, Nelson AE, Crossley KB. Prosthetic valve endocarditis due to Achromobacter xylosoxidans. Am Heart J. 1981; 101: 502.

31. Malek-Marin T, Arenas MD, Perdiguero M, Salavert-Lleti M, Moledous A, Cotilla E, et al. A case of endocarditis of difficult diagnosis in dialysis: could "pest" friends be involved? Clin Nephrol. 2009; 72: 405-409.

32. Sawant AC, Srivatsa SS, Castro LJ. Alcaligenes xylosoxidans endocarditis of a prosthetic valve and pacemaker in a 62-year-old woman. Tex Heart Inst J. 2013; 40: 95-98.

33. Bador J, Amoureux L, Blanc E, Neuwirth C. Innate aminoglycoside resistance of Achromobacter xylosoxidans is due to AxyXY-OprZ, an RND-type multidrug efflux pump. Antimicrob Agents Chemother. 2013; 57: 603-605.

34. Okoliegbe IN, Hijazi K, Cooper K, Ironside C, Gould IM. Longitudinal Surveillance and Combination Antimicrobial Susceptibility Testing of Multidrug-Resistant Achromobacter Species from Cystic Fibrosis Patients. Antimicrob Agents Chemother. 2020; 64: e01467-20.

35. Didelot X, Walker AS, Peto TE, Crook DW, Wilson DJ. Within-host evolution of bacterial pathogens. Nat Rev Microbiol. 2016; 14: 150-162.

36. Traglia GM, Almuzara M, Merkier AK, Adams C, Galanternik L, Vay C, et al. Achromobacter xylosoxidans: an emerging pathogen carrying different elements involved in horizontal genetic transfer. Curr Microbiol. 2012; 65: 673-678.

37. Lewis K. Riddle of biofilm resistance. Antimicrob Agents Chemother. 2001; 45: 999-1007.

38. Del Pozo JL. Biofilm-related disease. Expert Rev Anti Infect Ther. 2018; 16: 51-65.

39. Martino P, Micozzi A, Venditti M, Gentile G, Girmenia C, Raccah R, et al. Catheter-related right-sided endocarditis in bone marrow transplant recipients. Rev Infect Dis. 1990; 12: 250-257.