Infection (2011) 39:161–165
DOI 10.1007/s15010-010-0077-1

CASE REPORT

Septic shock, pneumonia, and soft tissue infection due to *Myroides odoratimimus*: report of a case and review of *Myroides* infections

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Received: 25 June 2010 / Accepted: 13 December 2010 / Published online: 19 January 2011

Abstract The genus *Myroides* comprises aerobic, yellow-pigmented, non-motile, non-fermenting gram-negative rods formerly classified as *Flavobacterium odoratum*. Members of the genus are widely distributed in the environment, especially in water, and usually behave as low-grade opportunistic pathogens, having been found to cause urinary tract infection, endocarditis, ventriculitis, and cutaneous infections in severely immunocompromised patients. We report a case of soft tissue infection, septic shock, and pneumonia due to *M. odoratimimus* in an immunocompetent male. To our knowledge, this is the first description of life-threatening infection caused by this organism in an immunocompetent host. We have also reviewed the medical literature on the genus *Myroides*.

Keywords Life-threatening infection · Myroides · immunocompetent host

Introduction

After the first isolation in 1923 [1], the organisms historically classified as part of the genus *Flavobacterium*, family *Bacteriaceae*, tribe *Chromobacteriaceae* included aerobic, yellow-pigmented, non-motile, non-fermenting gram-negative rods which produce a characteristic fruity odor and appear as lightly yellow-pigmented because of the presence of flexirubin pigment [2]. Among the members of this genus, *F. odoratum* was recognized to retain distinctive features (such as lack of gliding motility, good growth at 37°C, halotolerance, and several differences in fatty acid profile) which clearly warranted its reclassification. Therefore, in 1996, the new genus *Myroides* was created, in which two species deriving from a single phylogenetic branch (namely, *M. odoratus*, formerly *F. odoratum*; and a second species named *M. odoratimimus*) were included [3]. *Myroides* strains were primarily isolated from clinical sources. However, a number of studies have indicated that they are widely distributed in the aquatic environment: in recent years, three novel species (*M. pelagicus*, *M. profundi*, and *M. marinus*) were isolated from seawater [4–6].

Myroides strains usually behave as low-grade opportunistic pathogens, and have been found to be responsible for cases of urinary tract infection [7, 8], endocarditis [9], and ventriculitis [10]. Cutaneous infections (surgical wound infections [7, 11], cellulitis [12–16], and necrotizing fasciitis [17]) have also been described, often as a complication of septic dissemination. A precise discrimination of the causative species has become possible only in recent years thanks to molecular typing techniques, which have made it possible to recognize *M. odoratus* as the etiologic agent in cases of septic cellulitis [14, 15], and *M. odoratimimus* as responsible for cases of urinary infection [8] and one case of cellulitis associated with bacteremia [16]. Noticeably, *Myroides* spp. have always behaved as "opportunistic" pathogens so far, and all symptomatic infections have been observed in severely immunocompromised patients (Table 1).

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Table 1 Reports of infection due to members of the genus *Myroides* (formerly, *Flavobacterium odoratum*) as of October 2010

Reference	No. of cases	Organism	Comorbidity	Clinical setting	Outcome
Holmes et al. [7]	5	*F. odoratum*	Not known	Ischemic lower limb disease (1 patient); foot gangrene (1 patient); bladder carcinoma (1 patient); syringomyelia (1 patient); chronic renal impairment (1 patient)	N/A
Davis et al. [11]	1	*F. odoratum*	Alcoholism, malnutrition, left foot gangrene	Infection of amputation stump	Cured
MacFarlane et al. [10]	1	*F. odoratum*	Prematurity, malnutrition, hydrocephalus	Ventriculitis, bacteremia	Survived with sequelae
Prieur et al. [12]	1	*F. odoratum*	Acute cardiac failure, diabetes	Bacteremia and cellulitis	Cured
Hsueh et al. [17]	1	*F. odoratum*	HBV-related cirrhosis	Necrotizing fasciitis	Cured after amputation
Ferrer et al. [9]	1	*F. odoratum*	End-stage renal disease	Endocarditis, graft infection	Cured
Bachman et al. [13]	1	*F. odoratum*	COPD, chronic steroids	Bacteremia, recurrent cellulitis	Cured
Spanik et al. [28]	4	*F. odoratum*	Acute myeloid leukemia (2 patients); gastric cancer (1 patient); non-Hodgkin's lymphoma (1 patient)	Bacteremia, infected central venous catheter	Cured
Yağci et al. [8]	13	*M. odoratimimus*	Urinary neoplasm (4 patients); urinary stones (9 patients)	Pyuria	N/A
Green et al. [14]	1	*M. odoratus*	Ischemic heart disease	Bacteremia and cellulitis	Cured
Motwani et al. [15]	1	*M. odoratus*	Diabetes complicated by peripheral vascular disease	Bacteremia and cellulitis	Cured
Bachmeyer et al. [16]	1	*M. odoratimimus*	Alcoholic cirrhosis	Bacteremia and cellulitis	Cured
This case	1	*M. odoratimimus*	None	Septic shock, pneumonia, soft tissue infection	Cured

We report here a case of soft tissue infection, septic shock, and pneumonia due to *M. odoratimimus* in a fully immunocompetent male. To our knowledge, this is the first description of life-threatening infection caused by this organism in an immunocompetent host. We have also reviewed the medical literature on the genus *Myroides*.

Case presentation

A 72-year-old, otherwise healthy male with a history of slight-degree chronic hypertension presented to the emergency unit of our hospital after a severe farming accident. While farming, the man had been injured by the cutter bar of a combine harvester which severed his left arm and crushed his left hemithorax. Clinical examination revealed multiple excoriations, lacerated-contused wounds on the trunk, and supraclavicular subcutaneous emphysema; however, in spite of this, the patient was afebrile, conscious, and no focal neurological signs were detectable. His heart rate was 88/min and his blood pressure 120/60.

Laboratory tests showed the patient to be anemic (Hb, 9.1 g/dL) and have raised rhabdomyolysis indexes (serum creatine phosphokinase, 2,886 U/L, normal <200; serum myoglobin, >1,000 ng/mL, normal <110; urine peroxidase reaction positive in the absence of erythrocytes); however, no other significant biochemical abnormalities were observed. In particular, the renal function was normal and inflammation indexes were only slightly raised—his erythrocyte sedimentation rate (ESR) was 28 mm/h (normal <20) and his C-reactive protein (CRP) was 1.8 mg/dL (normal, <0.5). A computed tomography (CT) chest scan revealed a left pneumothorax, extensive bilateral hemothorax, and multiple costal fractures. Immediately after admission, the patient required surgical amputation of his left arm and, thereafter, he was transferred to the intensive care unit (ICU) due to hemorrhagic shock and acute respiratory failure. Two pleural drains were positioned and empiric antibiotic therapy with I.V. levofloxacin (500 mg b.i.d.) plus metronidazole (500 mg q.i.d.) was started. Following blood transfusion, the patient's hematocrit remained stable over time and his blood pressure was rapidly normalized without dopamine infusion.

Five days after hospitalization, the patient started to complain of acute tenderness in the left side of his chest and was found to have two large subcutaneous effusions with marked scar tissue overlying them; incision and drainage of these effusions was performed and the fluid collected was sent to the laboratory for culturing. A chest X-ray taken at the time suggested the onset of a ventilator-acquired pneumonia (VAP), since it revealed an extensive consolidation in the left lung, tending to converge to the homolateral hilum (Fig. 1); I.V. teicoplanin (400 mg/12 h for three doses, then 600 mg/daily) was thus added to the levofloxacin and metronidazole. Despite this, the patient started to deteriorate rapidly. He became restless, confused, and hypotensive (85/40). A presumptive diagnosis of septic shock was made, since the patient had fever with spikes of up to 39°C, leukocytosis (white blood cell count [WBC] = 17,000/mm^3), and high inflammatory markers (CRP = 18.4 mg/dL, normal, <0.5; ESR = 94 mm/h, normal <20; lactic dehydrogenase = 694 IU/L, normal <460; ferritin = 1,507, normal <250). A gram-negative rod was isolated from three separate sets of blood cultures drawn over a 24-h time period. The same organism was also isolated from a serum-purulent secretion in the amputation stump, the pleural drainage fluid, the bronchoalveolar lavage fluid, and from the pus drawn from the two subcutaneous effusions in the left hemithorax. The strain grew on nutrient agar and on MacConkey in spreading, yellow-pigmented colonies. It was identified as *Myroides* spp. by the Vitek 2 automated system (bioMérieux, Durham, NC, USA) and further speciated as *M. odoratimimus* by 16S rRNA sequencing, which revealed a 98% homology (458/464 base pair) with the database (GenBank) strain. The strain was resistant to the majority of agents tested (i.e., amikacin, aztreonam, cefepime, ceftazidime, ciprofloxacin, gentamicin, piperacillin, tobramycin, and trimethoprim/sulfamethoxazole) and fully susceptible only to imipenem, meropenem, piperacillin/tazobactam, and ticarcillin/clavulanate.

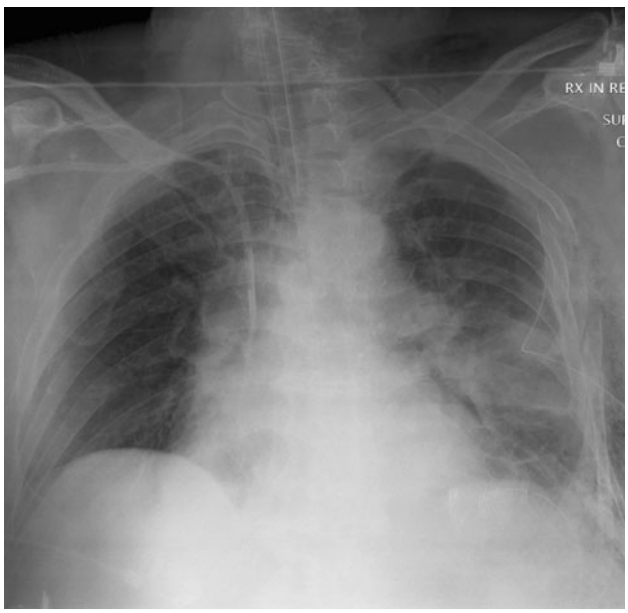

Fig. 1 Pneumonia due to *Myroides odoratimimus*. X-ray picture showing a large area of consolidation in the left middle lung field, tending to converge to the homolateral hilum

A cerebral CT scan failed to reveal focal lesions, and an echocardiogram showed no evidence of endocarditis. A dopamine infusion was started and the patient's antibiotic treatment was changed to a combination of I.V. piperacillin/tazobactam (4.5 g t.i.d.) and teicoplanin.

The patient became afebrile after one week, and the cellulitis on his trunk exhibited a progressive improvement. A chest X-ray taken 12 days after changing his antibiotics to piperacillin/tazobactam and teicoplanin showed an almost complete regression of pneumonia, and his CRP returned to normal within 14 days. After three more weeks (day 27 of hospital stay), the patient no longer required ventilation and was transferred to a medical unit, from where he was discharged home one week later. Following the isolation of *M. odoratimimus*, specific antibiotic treatment was given for a total of 28 days.

Discussion

Various recent studies have pointed out intrinsic features of *Myroides* spp. that could help to understand their capability to colonize ubiquitous environments. All of the species belonging to the genus have been found to produce surface-active compounds (cholic acid, deoxycholic acid, and their conjugates with glycine) using a biosynthetic conversion from cholesterol [18], and this may aid to explain the proven pathogenicity of *Myroides* spp. in biliary settings [19]. Myroilysin, a protease produced by *M. profundi*, has been characterized as an astacin-like metalloprotease displaying elastinolytic activity and playing a synergistic role with collagenase in collagen hydrolysis [20]. The presence of *Myroides* spp. isolates in mixed spp. biofilms has also been reported previously from the clinical [8] and food settings, observing that *M. odoratus* strains can contribute significantly to the attachment of *Listeria monocytogenes* to stainless steel food surfaces and to the resistance of this organism to eradication by chlorine [21]. In fact, at a microscopical level, *M. odoratus* cells formed a carpet that encased the intertwined, knitted chains of *L. monocytogenes* cells adhering to the perspex surface, suggesting that the *M. odoratus* carpet would form a physical barrier to chlorine exposure. Very recently [22], *M. odoratus* isolates were shown to display strong adherence profiles, with a preference for adherence at lower temperatures (about

21°C) and nutrient-rich environments with low hydrodynamic forces. In this light, it could be suggested that their wide distribution in the environment, as well as the ability to autoaggregate and coaggregate to form biofilms, might explain the ability of *Myroides* spp. to infect debilitated or immunosuppressed hosts, as a result of either contact with environmental strains or through nosocomial transmission. In the latter case, the source of these infections is often unknown, although water in the hospital environment is frequently suspected of carrying the organisms [23].

The treatment of *Myroides* infection is often difficult, since most strains are resistant to the β-lactams, including aztreonam and carbapenems, and exhibit variable susceptibility to aminoglycosides, quinolones, and sulfamethoxazole [24–26]. Based on the results of sensitivity testing studies published to date in the literature, the susceptibility of *M. odoratimimus* to various classes of antibiotics appears to mirror that of *M. odoratus*, but at a lower level [24–27]. Actually, the strain isolated from our patient retained susceptibility only to carbapenems and antipseudomonal penicillins, and was resistant to all other β-lactams tested (including aztreonam), as well as to aminoglycosides, quinolones, and trimethoprim/sulfamethoxazole. The production of chromosome-encoded metallo-β-lactamases has also been documented both in *M. odoratus* (TUS-1) and in *M. odoratimimus* (MUS-1) [27], and the importance of an accurate and reliable susceptibility testing (ideally, performed by microdilution techniques) has already been stressed when significant infections with *Myroides* strains are encountered [26].

F. odoratum has been traditionally regarded as an organism of ill-defined virulence [28]. *M. odoratus* was occasionally isolated from traumatically caused wounds [29], and, more recently, was found to cause only asymptomatic bacteremia in an outbreak of central venous catheter-associated bloodstream infection due to contaminated ampoules of water for injection [30]. However, the invasive potential of this pathogen has already been described in a patient with severe obstructive pulmonary disease under chronic corticosteroid therapy who developed recurrent cellulitis and bacteremia, where spread from the cutaneous site of origin to the bloodstream on two occasions was well documented [13]. Nevertheless, to date, only three cases of life-threatening infections have been reported, and all of them occurred in severely immunocompromised subjects [9, 10, 17]. One of these cases was a bacteremic necrotizing fasciitis caused by *F. odoratum* observed by Hsueh et al. in 1995 in a patient with HBV-related liver cirrhosis [17]; the authors speculated that the strain which caused this clinical picture in a 71-year-old farmer in Taiwan had gained access via a trivial wound contaminated with soil or water. Since the reclassification of *F. odoratum* to the new *Myroides* genus, *M. odoratimimus* has been reported to behave as a rare opportunistic organism, having been documented as a cause of both urinary tract infections in chronic urologic patients [8] and post-septic soft tissue infection in a severely immunocompromised and homeless patient [16]. The case described here appears pathogenetically very similar to the case of necrotizing fasciitis previously mentioned; in fact, both patients were elderly farmers who worked daily in the fields and could have acquired the infection via the environment, and our patient could well have acquired *M. odoratimimus* from an environmental source via a presumably massive post-traumatic inoculation. Although a nosocomial transmission cannot be theoretically excluded, the organism was not isolated from any other patient admitted into the ICU of our hospital after that episode. The septic shock manifesting itself one week after the patient's initial rescue was evidently related to a life-threatening *M. odoratimimus* infection.

In conclusion, although *M. odoratimimus* has, until now, only been regarded as an opportunistic pathogen and a rare cause of serious disease even in heavily immunocompromised subjects, we suggest that, in the light of our experience, clinicians should be aware that it may induce serious conditions even in immunocompetent hosts, especially if they have undergone major trauma.

Conflict of interest None.

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