

# A rare case of *Bordetella avium* pneumonia complicated by *Raoultella planticola*

Anna Lavrenko | Nataliia Digtar | Nataliia Gerasymenko | Igor Kaidashev

Internal Medicine Department No. 3  
with Phthysiology, Ukrainian Medical  
Stomatological Academy, Poltava, Ukraine

## Correspondence

Igor Kaidashev, Ukrainian Medical  
Stomatological Academy, Internal Medicine  
Department No.3 with Phthysiology, 23  
Shevchenko Str, Poltava 36011, Ukraine.  
Email: kaidashev@gmail.com

## Abstract

*Bordetella avium* pneumonia immunocompromised the patient with subsequent complication by a rare opportunistic *Raoultella planticola* infection, which became a nosocomial pathogen in the healthcare setting.

## KEYWORDS

*Bordetella avium*, moxifloxacin, pneumonia, *Raoultella planticola*

## 1 | INTRODUCTION

*Bordetella avium* is a respiratory pathogen isolated from patients with respiratory diseases. The definite pathological mechanism of *B avium* is currently unknown. We report a case of *B avium* pneumonia in a 52-year-old man who had regular contact with birds (turkeys, ducks, and geese). The patient was treated by moxifloxacin iv 7 days later, the patient had insufficient clinical effect of the treatment. Repeated sputum culture showed *Raoultella planticola*. We continued the antibiotic therapy for 10 days with clinical success. We suppose that *B avium* pneumonia immunocompromised the patient with subsequent *R planticola* infection. To our knowledge, it was the first case of *B avium* pneumonia complicated by a rare opportunistic pathogen *R planticola*.

*Bordetella avium* (*B avium*) is a Gram-negative, nonfermentative, strictly aerobic, motile bacterium from the genus *Bordetella*, which has been isolated from patients with respiratory disease such as cystic fibrosis.<sup>1</sup>

In general, *B avium* is a respiratory pathogen causing bordetellosis, a common avian disease in turkeys. Specific adherence and damage to the respiratory epithelia are crucial steps of pathogenesis, but knowledge about the mechanism and the variety of virulence in field strains is limited.<sup>2</sup>

During pathogenesis in turkeys, *B avium* attaches specifically to ciliated respiratory epithelial cells. Ciliated cells

are extruded from the epithelium and hyperplasia results in a respiratory epithelium composed of immature cells. Mucus is depleted, and there is eventual infiltration by lymphocytes and macrophages.<sup>3,4</sup>

It was shown that *B avium* does not carry genes that encode pertussis toxin or adenylate cyclase toxin.<sup>5</sup> *B avium* has yet-unidentified virulence factors, which may contribute to their ability to cross over from an animal host to an opportunistic human pathogen. In turkey tracheal explants, *B avium* supernatant factors induced apoptosis in ciliated cells.<sup>6</sup>

Recently, it was shown that *B avium* can produce cellulose which may be important for biofilm formation.<sup>7</sup>

Virulence-associated genes *bvgA*, *fimA*, and *fhaB* (encoded for hemagglutinin) were detected in *B avium* isolates.<sup>8</sup> The *fhaB* is an important adhesion in the classical *Bordetella*, and its expression is regulated by *bvgA*. Flagella genes play an important role as virulence-associated factors involved in the motility and the attachment to the host cells.<sup>9</sup>

The abuse of antimicrobials at the poultry farms led to the development of antimicrobial-resistant bacterial strains. Literature data indicated occurrence of multidrug resistance among turkey *B avium*-identified isolates with resistance to penicillin, ceftiofur, nalidixic acid, lincomycin, erythromycin, and oxytetracycline.<sup>10</sup> This resistance may be country-specific.<sup>11</sup>

Patients with signs and symptoms, clinically consistent with respiratory syndromes caused by *Bordetella*, respond

This is an open access article under the terms of the Creative Commons Attribution License, which permits use, distribution and reproduction in any medium, provided the original work is properly cited.

© 2020 The Authors. *Clinical Case Reports* published by John Wiley & Sons Ltd.

to antibacterial treatment. Human infection with *B avium* may present a challenge for antimicrobial drug treatment due to resistance. The presence of unidentified virulence factors in *B avium* may contribute to their ability to develop into an opportunistic human pathogen from an animal host.<sup>12</sup>

*Raoultella planticola* is a Gram-negative, aerobic, non-motile, encapsulated rod-shaped bacterium belonging to the family Enterobacteriaceae.<sup>13</sup> Typically considered as a pathogen only in the immunocompromised patients, *R planticola* has been shown to cause various infections in organs such as the lungs, pancreas, skin, liver, prostate, conjunctiva, and gallbladder.<sup>14-17</sup>

To our knowledge, we present the first case of *B avium* pneumonia in a patient with direct history of attributable environment exposure risk complicated by a rare opportunistic pathogen *Raoultella planticola* (*R planticola*).

## 2 | CASE HISTORY AND EXAMINATION

A 52-year-old man with a 25-pack year smoking history and medical history of arterial hypertension, dyscirculatory encephalopathy and chronic pyelonephritis presented to our department with complaints of weakness, fatigue, cough with mucopurulent sputum, and right-sided moderate chest pain for 5 days. He received paracetamol 500 mg b.i.d., enalapril 10 mg, bisoprolol 10 mg, and acetylsalicylic acid 75 mg. On admission, physical examination revealed a mildly ill-appearing white male, alert, and oriented, with acrocyanosis.

His vitals were as follows: temperature 40°C, blood pressure 115/70, pulse 73, respiratory rate of 23 breaths per minute, weight 86.0 kg, and height 180.0 cm. The oxygen saturation was 92% on room air.

Auscultation of his lungs revealed rales bilaterally with crackle on the right lower lung field.

Blood count showed white blood cells (WBC) of 5600/mm<sup>3</sup> with 85% neutrophils and 7% lymphocytes, hemoglobin of 12.1 g/dL, and erythrocyte sedimentation rate 55 mm per hour.

Serum chemistry showed common bilirubin 11.6 µmol/L, creatinine 87 µmol/L, aspartate aminotransferase 32 IU/L,

alanine aminotransferase 34 IU/L, total protein 67 g/L, negative HBV and HCV markers, procalcitonin 0.12 µg/L (normal range <.06), and creatinine clearance 106.8 mL/min.

Sputum Gram stain: epithelial cells <10, polymorphonuclear leukocytes >25, gram+ cocci chains rare +1, gram+ cocci pairs few 2+, gram- rods rare 1+, and fungal element rare 1+.

A plain chest radiography on admission showed a right-sided pleuropneumonia predominantly in the middle lobe (Figure 1).

## 3 | DIFFERENTIAL DIAGNOSIS, INVESTIGATIONS, AND TREATMENT

Initially, we suspected bacterial pneumonia. Empirically, ceftriaxone 1000 mg (one time), moxifloxacin 400 mg, and ambroxol were given intravenously. Sputum cultures were prepared and analyzed according to EUCAST recommendation. Sputum culture showed *Metylobacterium mesophilicum*, Viridans group streptococci, and *Candida* spp. *M mesophilicum* isolate was identified as *Bordetella avium* with a sensitivity to most antibiotics (Table 1). Blood culture was sterile. We diagnosed pneumonia caused by *B avium*. Additional investigation revealed that the patient had a private bird farm and regular contact with turkeys, ducks, and geese.

Seven days after hospitalization, dyspnea, cough, and sputum production were not alleviated. Laboratory analysis was as follows: the WBC count of 4300 mm<sup>3</sup> (neutrophils 63%, lymphocytes 30%) and erythrocyte sedimentation rate 44 mm/h. A plain chest radiography showed negative dynamics, right-sided infiltration in S6. An axial chest computed tomography (CT) showed evidence of both sided lower lobe infiltrates with pointed calcificates. Repeated sputum culture (on day 7 after hospitalization) showed *Klebsiella pneumonia*, *Hemophilus parainfluenzae*, and *Rothia* (*Stomatococcus*) *mucilanginous*. Isolate of *K pneumoniae* was identified as *Raoultella planticola* with a sensitivity to antibiotics (Table 1). Blood culture was sterile. In serum, no antibodies to HIV were detected. We continued the therapy with moxifloxacin up to 10 days.

**TABLE 1** Antibiotic susceptibility of isolates from pneumonia patients sputum

		Amoxicillin/		Chloramphenicol	Doxycycline	Co-trimoxazole	Amikacinum	Ciprofloxacin	Levofloxacin
		Amoxicillin	Clavulanic acid						
Day 1	<i>Bordetella avium</i>	S	S	S	S	S	S	S	S
	<i>Hemophilus parainfluenzae</i>	R	R	S	R	R	I	R	I
Day 7	<i>Raoultella planticola</i>	R	R	S	I	R	S	I	S

Note: Abbreviations: -, not done; I, intermediate; R, resistant; S, susceptible.





an elderly person who had pulmonary problems along with other medical conditions, and each belonged to a population typically susceptible to opportunistic infections. Signs and symptoms were clinically consistent with respiratory syndromes caused by *Bordetella*.<sup>12</sup>

To the rare occurrence of human infection, risk factors associated with *B avium* infection are largely deduced from the few reported cases. These include an immunocompromised state and exposure to environmental factors, such as contacts with birds (turkeys, ducks, and geese). Identification of *Bordetella* species may have serious consequences for treatment in some patients.<sup>19</sup> Our patient worked at a private bird farm. He took care of birds every day. On admission, he had lymphopenia (7%, 392/mm<sup>3</sup>). We suppose that lymphopenia was due to an immunosuppressive activity of *B avium*. There are no sufficient data about immunosuppressive activity of *B avium*. Nevertheless, other *Bordetella* spp. (such as *B pertussis* and *B bronchiseptica*) stimulated immunosuppressive response characterized by increased interleukin-10 and decreased interferon-gamma production.<sup>20,21</sup> The strain of *B avium* was susceptible to many antimicrobials, including moxifloxacin. Such wide susceptibility can be explained by the origin of this strain, from a private bird farm without antimicrobial technologies.

Seven days after moxifloxacin therapy, we did not register clinical success. Primary *K pneumonia* was isolated from the patient's sputum. Later, isolate was identified as *R planticola* with intermediate susceptibility to doxycycline and ciprofloxacin, but susceptible to moxifloxacin. These data support the difficulties in identifying *Klebsiella* strains of clinical origin.<sup>22</sup>

*Raoultella planticola* has traditionally been considered a nonclinical, aquatic, botanical, and soil organism.<sup>13</sup>

Since its initial description, 23 cases of human infections with *R planticola* have been reported.<sup>14</sup> Thus, *R planticola* may be an emerging pathogen, causing significant infections in multiple different organ systems. *R planticola* should no longer be considered as a harmless environmental organism, but rather as an invasive organism, requiring prompt diagnosis and treatment.

The possible scenarios for *R planticola*'s natural course of infection were suggested: (a) trauma infection, (b) nosocomial infection, (c) immunocompromised infection, and (d) enteric fever and bacteremia in immunocompetent patients.<sup>23</sup>

We suggest that our patient had nosocomial *R planticola* infection due to immunocompromising by previous *B avium* pneumonia.

The majority of these patients, infected by *R planticola*, were successfully treated with empirical antibiotics.<sup>24</sup> However, like *Klebsiella* spp., *R planticola* has the ability to acquire antibiotic resistance.<sup>25</sup> Recently, there is evidence of carbapenem-resistant strains of *R planticola*.<sup>26</sup>

Carbapenemase production provided this resistance of *R planticola*.<sup>27</sup> Our patient had *R planticola* strain resistant to

amoxicillin, amoxicillin/clavulanic acid, and co-trimoxazole. In the literature, there is evidence of successful treatment of such patients with fluoroquinolones.<sup>28</sup> Thus, in our case, *B avium* and *R planticola* were susceptible to moxifloxacin, and moxifloxacin provided clinical success in pneumonia treatment.

## 6 | CONCLUSION

We report, to our knowledge, the first case of *B avium* pneumonia complication by a rare opportunistic pathogen *R planticola* in a patient with direct attributable environment exposure risk—the work at a bird farm. The problems of *B avium* identification still persist. We suppose that *B avium* induced lymphopenia in the patient and immunocompromised him. In this case, *R planticola* became a nosocomial pathogen in the healthcare setting. *R planticola* had susceptibility to many antibiotics with the exception of amoxicillin, clavulanic acid, and co-trimoxazole in the treatment of pneumonia.

## ACKNOWLEDGMENTS

This work was supported as a part of clinical trial ML-3341-306 “A Phase 3 Multicenter, Randomized, Double-Blind, Comparator-Controlled Study to Evaluate the Safety and Efficacy of Intravenous to Oral Delafloxacin in Adult Subjects with Community-Acquired Bacterial Pneumonia” EudraCT Number: 2015-003026-14.

## CONFLICT OF INTEREST

The authors do not have any conflicts of interest to declare.

## AUTHOR CONTRIBUTIONS

AL: involved in data acquisition and manuscript preparation. ND: involved in clinical case management and manuscript preparation. NG: involved in clinical case management and manuscript preparation. IK: involved in concepts, study design, definition of intellectual content, data analysis, manuscript preparation, manuscript editing, and manuscript review.


## ETHICAL APPROVAL

The study has been approved by the appropriate ethics committee and has therefore been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments.

## ORCID

Anna Lavrenko  <https://orcid.org/0000-0003-2789-9135>

Nataliia Digtar  <https://orcid.org/0000-0002-8238-1876>

Nataliia Gerasymenko  <https://orcid.org/0000-0001-9002-3641>

Igor Kaidashev  <https://orcid.org/0000-0002-4708-0859>



## REFERENCES

- Spilker T, Liwiński AA, LiPuma JJ. Identification of *Bordetella* spp. in respiratory specimens from individuals with cystic fibrosis. *Clin Microbiol Infect*. 2008;14(5):504-506.
- Knab R, Petersen H, Lin HJ, Meixner M, Rautenschlein S, Jung A. In vitro characterization and genetic diversity of *Bordetella avium* field strains. *Avian Pathol*. 2019;10:1-11.
- Saif YM, Moorhead PD, Whitmoyer RE. Scanning electron microscopy of tracheas from turkey poults infected with *Alcaligenes faecalis*. *Avian Dis*. 1981;25(3):730-735.
- Arp LH, Fagerland JA. Ultrastructural pathology of *Bordetella avium* infection in turkeys. *Vet Pathol*. 1987;24(5):411-418.
- Sebahia M, Preston A, Maskell DJ, et al. Comparison of the genome sequence of the poultry pathogen *Bordetella avium* with those of *B. bronchiseptica*, *B. pertussis*, and *B. parapertussis* reveals extensive diversity in surface structures associated with host interaction. *J Bacteriol*. 2006;188(16):6002-6015.
- Miyamoto DM, Ruff K, Beach NM, et al. *Bordetella avium* causes induction of apoptosis and nitric oxide synthase in turkey tracheal explant cultures. *Microbes Infect*. 2011;13(10):871-879.
- McLaughlin K, Folorunso AO, Deeni YY, et al. Biofilm formation and cellulose expression by *Bordetella avium* 197N, the causative agent of bordetellosis in birds and an opportunistic respiratory pathogen in humans. *Res Microbiol*. 2017;168(5):419-430.
- Temple LM, Miyamoto DM, Mehta M, et al. Identification and characterization of two *Bordetella avium* gene products required for hemagglutination. *Infect Immun*. 2010;78(6):2370-2376.
- Linz B, Ivanov YV, Preston A, et al. Acquisition and loss of virulence-associated factors during genome evolution and speciation in three clades of *Bordetella* species. *BMC Genomics*. 2016;17(1):767.
- Eldin WFS, Abd-El Samie LK, Darwish WS, Elewa YHA. Prevalence, virulence attributes, and antibiogram of *Bordetella avium* isolated from turkeys in Egypt. *Trop Anim Health Prod*. 2020;52(1):397-405.
- Szabó R, Wehmann E, Magyar T. Antimicrobial susceptibility of *Bordetella Avium* and *Ornithobacterium Rhinotracheale* strains from wild and domesticated birds in Hungary. *Acta Vet Hung*. 2015;63(4):413-424.
- Harrington AT, Castellanos JA, Ziedalski TM, Clarridge JE 3rd, Cookson BT. Isolation of *Bordetella avium* and novel *Bordetella* strain from patients with respiratory disease. *Emerg Infect Dis*. 2009;15(1):72-74.
- Bagley ST, Seidler RJ, Brenner DJ. *Klebsiella planticola* sp. nov.: A new species of enterobacteriaceae found primarily in nonclinical environments. *Curr Microbiol*. 1981;6(2):105-109.
- Westerveld D, Hussain J, Aljaabareh A, Ataya A. A rare case of *Raoultella planticola* pneumonia: an emerging pathogen. *Respir Med Case Rep*. 2017;21:69-70.
- O'Connell K, Kelly J, Niriain U. A rare case of soft-tissue infection caused by *raoultella planticola*. *Case Rep Med*. 2010;2010:134086.
- Koukoulaki M, Bakalis A, Kalatzis V, et al. Acute prostatitis caused by *Raoultella planticola* in a renal transplant recipient: a novel case. *Transpl Infect Dis*. 2014;16(3):461-464.
- Vassallo J, Vella M, Cassar R, Caruana P. Four cases of *Raoultella planticola* conjunctivitis. *Eye (Lond)*. 2016;30(4):632-634.
- Riffelmann M, Wirsing von König CH, Caro V, Guiso N, Pertussis PCR Consensus Group. Nucleic acid amplification tests for diagnosis of bordetella infections. *J Clin Microbiol*. 2005;43(10):4925-4929.
- Bos AC, Beemsterboer P, Wölfs TF, Versteegh FG, Arets HG. *Bordetella* species in children with cystic fibrosis: what do we know? The role in acute exacerbations and chronic course. *J Cyst Fibros*. 2011;10(5):307-312.
- Skinner JA, Pilione MR, Shen H, Harvill ET, Yuk MH. *Bordetella* type III secretion modulates dendritic cell migration resulting in immunosuppression and bacterial persistence. *J Immunol*. 2005;175(7):4647-4652.
- McGuirk P, McCann C, Mills KH. Pathogen-specific T regulatory 1 cells induced in the respiratory tract by a bacterial molecule that stimulates interleukin 10 production by dendritic cells: a novel strategy for evasion of protective T helper type 1 responses by *Bordetella pertussis*. *J Exp Med*. 2002;195(2):221-231.
- Monnet D, Freney J, Brun Y, Boeufgras JM, Fleurette J. Difficulties in identifying *Klebsiella* strains of clinical origin. *Zentralbl Bakteriol*. 1991;274(4):456-464.
- Ershadi A, Weiss E, Verduzco E, Chia D, Sadigh M. Emerging pathogen: a case and review of *Raoultella planticola*. *Infection*. 2014;42(6):1043-1046.
- Chun S, Yun JW, Huh HJ, Lee NY. Low virulence? Clinical characteristics of *Raoultella planticola* bacteremia. *Infection*. 2014;42(5):899-904.
- Tseng SP, Wang JT, Liang CY, Lee PS, Chen YC, Lu PL. First report of bla(IMP-8) in *Raoultella planticola*. *Antimicrob Agents Chemother*. 2014;58(1):593-595.
- Xu M, Xie W, Fu Y, Zhou H, Zhou J. Nosocomial pneumonia caused by carbapenem-resistant *Raoultella planticola*: a case report and literature review. *Infection*. 2015;43(2):245-248.
- Zamora JAG, Corzo-Pedroza M, Alvarez MR, Martinez OV. Carbapenemase-producing *raoultella planticola*: a rare cause of pneumonia and bacteremia. *Diseases*. 2018;6(4):E94.
- Pan Z, Liu R, Zhang P, Zhou H, Fu Y, Zhou J. Combination of tigecycline and levofloxacin for successful treatment of nosocomial pneumonia caused by New Delhi Metallo- $\beta$ -Lactamase-1-Producing *Raoultella planticola*. *Microb Drug Resist*. 2017;1:127-131.

**How to cite this article:** Lavrenko A, Digtar N, Gerasymenko N, Kaidashev I. A rare case of *Bordetella avium* pneumonia complicated by *Raoultella planticola*. *Clin Case Rep*. 2020;00:1-5. <https://doi.org/10.1002/ccr3.2800>