

A rare bloodstream infection: *Bacillus mycooides*

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KEYWORDS

Bacillus mycooides, bacterial spores, bloodstream infection, environmental causes

ABSTRACT

A 65-year-old male was admitted to the Intensive Care Unit after being resuscitated because of a hypoxic cardiac arrest caused by influenza. Blood cultures taken at time of admission surprisingly grew *Bacillus mycooides*, a spore-producing apathogenic agriculture bacterium. We collected culture samples at his barge. Although we did not culture *Bacillus mycooides*, we did find multiple other *Bacillus* species. We hypothesised that our patient was colonised from the freights of his barge, and bloodstream infection occurred during resuscitation with either the bacterium itself or its spores. To our knowledge, this is the first report on bloodstream infection with *Bacillus mycooides* in a human patient.

INTRODUCTION

In this case report, we present a rare bloodstream infection: *Bacillus mycooides*, a spore-producing apathogenic agriculture bacterium.

Medical investigation in the field is not common practice in the Netherlands in cases of unexpected or rare pathogens, except for environmental assessment and source investigation by the municipal health service and the Dutch National Institute for Public Health and Environment (RIVM) in cases of tuberculosis, legionellosis and Q-fever.^{1,3}

CASE REPORT

A 65-year-old male was admitted to the Intensive Care Unit (ICU), after an out-of-hospital cardiac arrest.

What was known on this topic?

Bacillus mycooides, a spore-producing Gram-positive rod-shaped bacterium, is an apathogenic bacterium. It is part of the *Bacillus cereus sensu lato* (or *Bacillus cereus* group), together with species including *Bacillus cereus* and *Bacillus anthracis*.

What does this add?

To our knowledge, this is the first report on bloodstream infection with *Bacillus mycooides* in a human patient. In such rare cases of infection with *Bacillus mycooides*, exposition of agricultural origin should be taken into consideration.

Bacillus mycooides is able to produce spores and grows haemolytically on blood agar plates (bèta-haemolysis). This latter property differentiates it from *Bacillus anthracis*, which grows non-haemolytically.

Medical history revealed hypertension, cutaneous lupus erythematoses, chronic hyponatremia and Waldenström disease. Known prescribed medications were clobetasol balm, dabigatran, hydroxychloroquine, hydroxocobalamin injections, lercanidipine, lisinopril and pantoprazole. He was not recently treated with systemic immunomodulatory medication. He had not responded to the invitation for the annual Influenza vaccination. He had been coughing for several days, when a friend found him in a dyspnoeic state inside the cabin of his barge. He had not been in contact with the water. When ambulance personnel arrived, he succumbed and they had to resuscitate him inside the cabin because of pulseless electrical activity. Struggling to accomplish intravenous access, they placed an intra-osseous needle (ION). Return of spontaneous circulation was gained after 20 minutes. On presentation at the Emergency Department, his blood pressure was 146/83 mmHg, his heart rate 103 beats/minute, his oxygen saturation 98% on mechanical ventilation with fraction of inspired oxygen 35%, and his

temperature 37.7 °C. Central venous and arterial lines were placed and the ION was removed. Electrocardiogram and cardiac ultrasound did not show signs of myocardial ischemia or pulmonary emboli. Chest X-ray showed redistribution and pleural effusion suspect for pulmonary oedema, and no clear signs of pneumonia. Since the patient developed pulseless electrical activity while in a dyspnoeic state, we assumed he had suffered from a hypoxic cardiac arrest.

He was admitted to the ICU for post-resuscitation therapeutic thermoregulation. Influenza A virus testing proved positive and treatment with oseltamivir was initiated. He gradually regained consciousness and was extubated at day four. That same day, to our surprise, four different blood cultures taken at time of admission proved positive for spore-producing Gram-positive rod-shaped bacteria. There were no clinical signs of bacteraemia: temperature was normal, circulation stable without support, and laboratory results showed declining leukocyte counts and C-reactive protein. Considering *Clostridium*, we started treatment with penicillin. To exclude and treat possible indwelling catheter infection, we removed the central venous lines and replaced the arterial line under penicillin treatment. Cultures of these lines remained negative. At day five, *Bacillus mycoides* were identified by matrix-assisted laser desorption/ionization (MALDI-TOF) (figure 1). Growth on blood agar plates showed haemolysis. Despite being known as an apathogenic bacterium, we chose to treat this *Bacillus* because of the bloodstream infection and switched antibiotic treatment to vancomycin because of penicillin resistance. We excluded any endogenous infection focus with CT scan of the thorax/abdomen. Blood cultures taken at day six and seven remained negative, as were sputum cultures throughout admission. Our patient recovered well, though still

suffering the sequelae of postanoxic encephalopathy. He was discharged from the ICU at day seven.

DISCUSSION

In order to understand the cause of events which led to this unexpected and uncommon bloodstream infection, we had to investigate the origin of this case of *Bacillus mycoides*. The *Bacillus cereus sensu lato* (or *Bacillus cereus* group) is comprised of eight different Gram-positive species: *Bacillus cereus sensu stricto*, *Bacillus thuringiensis*, *Bacillus weihenstephanensis*, *Bacillus mycoides*, *Bacillus pseudomycoides*, *Bacillus cytotoxicus*, and *Bacillus anthracis*. They have the ability to express a number of enterotoxins and as spore-formers, they can present an increased risk to food safety since spores may survive food-processing controls such as pasteurisation. *Bacillus cereus* is among the most important enterotoxigenic foodborne pathogens, generally causing either emetic or diarrheal symptoms.⁴ Though isolated and uncomplicated in the majority of cases, it is increasingly being reported to be a cause of serious and potentially fatal non-gastrointestinal tract infections, such as endocarditis, osteomyelitis, and severe cutaneous infections.⁵ The other well-known pathogen species from this group is *Bacillus anthracis*, the etiological agent for anthrax.⁶

Bacillus mycoides is probably the least recognized species; in contrast to *Bacillus cereus* and *anthracis* it is not pathogenic and it does not have the insecticidal activity of *Bacillus thuringiensis* (figure 2, panel A).⁶ *Bacillus mycoides* is ubiquitous in the soil and rhizosphere. Like *Bacillus subtilis*, some *mycoides* isolates have beneficial plant growth and biocontrol activity,⁷ and hence, are found in natural compost and anti-fungal bio-pesticides (figure 2, panels B, C, D). Since it is not a human pathogen, infections with *Bacillus mycoides* are rare. *Bacillus mycoides* is able to produce spores, and grows haemolytically on blood agar plates (beta-haemolysis). This latter property differentiates it from *Bacillus anthracis*, which grows non-haemolytically.⁸ In retrospect, it could have helped us differentiate between *Bacillus mycoides* and *Clostridium difficile* (because the latter also grows non-haemolytically), when haemolytical growth would have been observed prior to identification by MALDI-TOF.

We concentrated on the agricultural origin of *Bacillus mycoides*. Our patient was not a gardener; he did not work with plants, compost, or manure other than the freights of his barge. Since he had been transporting agricultural freights for years (wheat, corn, and residual waste of palm/turnip/soy meant for cattle feeding), it is likely that *Bacillus* species like *subtilis* and *mycoides* and their spores entered

Figure 1. Gram stain of blood culture with Gram-positive rod-shaped bacteria: *Bacillus mycoides*



Figure 2. Examples of insecticide, natural compost, and bio-pesticides, containing *Bacillus thuringiensis* (panel A), *Bacillus subtilis* (panels B, C), and *Bacillus mycoides* (panel D).



the barge, either as natural component of soil and plant roots, or as part of compost or pesticides.

The bacteria and their spores then colonised the skin of our patient. During resuscitation, the bacteria or their spores were introduced transdermally into the bloodstream through placement of either the ION or the venous and arterial lines. In order to test this hypothesis, we were granted permission to take culture samples from the hold and the water supply system of the barge (figure 3). Although subsequent cultures did not show *Bacillus mycoides*, we did find multiple other *Bacillus* species, in particular, *subtilis* and even *cereus* (table 1). Routine surveillance cultures of the patient's skin and throat did not grow *Bacillus*. However, because *Bacillus mycoides* is a spore-producing bacterium, the infection could also have originated from just the spores present on the ship and the patient's skin.

CONCLUSION

To our knowledge, this is the first report on bloodstream infection with *Bacillus mycoides* in a human patient. It seems likely that colonisation and subsequent transdermal bloodstream infection (with either the bacterium itself or its spores) originated from the ship's holds and freights. In such rare cases of infection with *Bacillus mycoides*, exposition of agricultural origin should be taken into consideration. Medical investigation in the field (patient homes, companies, public places) can contribute to the diagnostic process.

DISCLOSURES

All authors declare no conflicts of interest. No funding or financial support was received.

Figure 3. Pictures of our visit to the barge, in order to collect cultures from the hold and the water supply system. The 55-meter-long barge, with 560 tons of cargo capacity (panel A), the interior of the hold (panel B), one of several drainpipes (panel C).



Table 1. Results of the cultures collected at the barge

Culture location barge	Microorganism	Quantity
Floor of the hold #1	<i>Bacillus cereus</i>	+
	<i>Serratia fonticola</i>	+++
	<i>Serratia liquefaciens</i>	+++
	Mixed flora	+++
Floor of the hold #2	<i>Bacillus circulans</i>	++
	<i>Bacillus pumilus</i>	+
	Mixed flora	+++
Floor of the hold #3	<i>Bacillus pumilus</i>	++
	Mixed flora	++
Floor of the hold #4	Mixed flora	++
Floor of the hold #5	Mixed flora	++
Floor of the hold #6	<i>Bacillus cereus</i>	+
	<i>Staphylococcus xylosum</i>	+
	Mixed flora	+++
Wall of the hold #1	<i>Bacillus circulans</i>	++
	<i>Bacillus pumilus</i>	++
	Mixed flora	++
Wall of the hold #2	<i>Bacillus subtilis</i>	+
	Mixed flora	+
Wall of the hold #3	<i>Bacillus licheniformis</i>	+
	<i>Bacillus subtilis</i>	+
	Mixed flora	+
Wall of the hold #4	<i>Bacillus circulans</i>	+
	<i>Bacillus pumilus</i>	++
	<i>Pseudomonas stutzeri</i>	+++
	Mixed flora	+++
Drain pipe of the hold #1	Mixed flora	+++
Liquid drain pipe #1	Mixed flora	+++
Drain pipe of the hold #2	<i>Bacillus pumilus</i>	++
	Mixed flora	++
Liquid drain pipe #2	Mixed flora	+
Sample outside water surrounding barge	Mixed flora	+++
Sample fresh water tank barge	Mixed flora	+

REFERENCES

- Den Boer JW, Yzerman EP, Schellekens J, et al. A large outbreak of Legionnaires' disease at a flower show, the Netherlands, 1999. *Emerg Infect Dis.* 2002;8:37-43.
- Sonder GJ, van den Hoek JA, Bovee LP, et al. Changes in prevention and outbreak management of Legionnaires disease in the Netherlands between two large outbreaks in 1999 and 2006. *Euro Surveill.* 2008;13: pii: 18983.
- Delsing CE, Kullberg BJ, Bleeker-Rovers CP. Q fever in the Netherlands from 2007 to 2010. *Neth J Med.* 2010;68:382-7.
- Walker-York-Moore L, Moore SC, Fox EM. Characterization of enterotoxigenic *Bacillus cereus* sensu lato and *Staphylococcus aureus* isolates and associated enterotoxin production dynamics in milk or meat-based broth. *Toxins (Basel).* 2017 Jul 15;9(7). Pii: E225. doi: 10.3390/toxins9070225.
- Bottone EJ. *Bacillus cereus*, a volatile human pathogen. *Clin Microbiol Rev.* 2010;23:382-98.
- Okinaka RT, Keim P. The phylogeny of *Bacillus cereus* sensu lato. *Microbiol Spectr.* 2016;4. doi: 10.1128/microbiolspec.TBS-0012-2012.
- Yi Y, de Jong A, Frenzel E, et al. Comparative transcriptomics of *Bacillus mycoides* strains in response to potato-root exudates reveals different genetic adaptation of endophytic and soil isolates. *Front Microbiol.* 2017;8:1487.
- Richtlijn antrax: Rijksinstituut voor Volksgezondheid en Milieu, bijlage 3: Isolatie en identificatie *Bacillus anthracis* [Internet, cited 1 June 2019]. Available from: <https://lci.rivm.nl/richtlijnen/antrax#samenvatting>.