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B. Bronchiseptica empyema necessitans, a case report

Samantha Wray[1*], Nikko Rowe A. Tabliago[2] and Richard Lueking[2]

Abstract

Background Empyema necessitans is an uncommon complication of an empyema, where pus in the pleural cavity extends into the chest wall. Both medical and surgical management are required. Here we have identified the first reported case of empyema necessitans caused by *Bordetella bronchiseptica*.

Case presentation A 60-year-old female dog trainer initially presented with a right chest wall lesion. Imaging showed a right-sided empyema and chest wall fistulization. Multiple Gram stains and cultures isolated *Bordetella bronchiseptica*. After several courses of antibiotics, imaging showed a chronic pleural collection with communication to a chest wall gas-fluid collection resembling empyema necessitans. Culture re-demonstrated *Bordetella bronchiseptica*. She was given a six-week course of oral moxifloxacin and underwent a Clagett window.

Conclusions While *Bordetella bronchiseptica* has been previously exclusive to animals, it is an emerging zoonosis. Empyema necessitans because of repeated animal exposure is an unusual complication that had yet to be seen with this microorganism.

Keywords *Bordetella bronchiseptica*, Empyema necessitans, Infectious diseases, Case report

Background

Empyema necessitans (EN) is an uncommon complication of an empyema, where the collection of purulent material in the pleural cavity extends into the surrounding tissues of the chest wall. EN can be a complication of previous surgery, trauma, bacterial pneumonia, or parapneumonic effusion. Treatment of EN commonly consists of both medical and surgical management often requiring chest tubes, surgical decortication, and extended antimicrobial treatment. The most common causal agents identified behind EN are *Mycobacterium tuberculosis*, *Actinomyces*, with rare reports of other causative agents such as methicillin resistant *Staphylococcus aureus* [1, 2]. However, we have identified the first reported case of EN caused by *Bordetella bronchiseptica.* An obligate aerobic gram-negative coccobacillus, *B. brochiseptica* was first identified as a separate entity to *B. pertussis* in the 1930's. Since then, it has become known as the culprit behind the respiratory illness, "kennel cough," in domesticated dogs and cats. Since identification, it has also been implicated in cases of post-surgical/post-traumatic meningitis, bacteremia, and pancreatic abscesses in immunocompromised hosts [3–6]. However, when isolated from humans, it is most commonly found in immunocompromised hosts with upper and lower respiratory infections [6, 7]. We present a case of *B. bronchiseptica* causing recurrent EN in a presumed immunocompetent host.

*Correspondence:
Samantha Wray
saw304@musc.edu
[1]Division of Hospital Medicine, Department of Medicine, Medical University of South Carolina, 135 Rutledge Ave 8th Floor, Charleston, SC 29425, USA
[2]Division of Infectious Diseases, Department of Medicine, Medical University of South Carolina, Charleston, SC, USA

Case presentation

The patient is a 60-year-old female with a pertinent history of remote non-small cell lung cancer status post chemotherapy/radiation, lobectomy, and chest wall resection with subsequent mesh for reconstruction, which were all completed in 2012. She was presumed to be immunocompetent at admission as she had no history of HIV, prior immunodeficiencies, or active prescription medications that would modulate the immune system. She presented to her primary care provider (PCP) in March 2023 for a self-reported tick bite and exam showed an erythematous papule with central opening and purulent drainage on the right side of her chest. Review of systems was only positive for a dry cough. At that time, she worked as a behavioral trainer and foster for domesticated dogs; she did not recall any chest wall trauma, injuries, or scratches from these pets. Her PCP prescribed a 21-day course of doxycycline 100 mg twice daily for presumed vector-borne disease and cellulitis based on documentation and the affected area improved. Over the course of several weeks, she received additional treatment with cephalexin 500 mg three times daily and doxycycline 100 mg twice daily to manage this recurring lesion. Her symptoms progressed to include a productive cough and chest fullness. When the lesion started to drain purulent material, this was sent for bacterial cultures. The Gram stain did not show any microorganisms but cultures grew *B. bronchiseptica*.

CT chest was then obtained and was found to have a right-sided empyema with fistulization to the chest wall in the location of prior radiation, resection, and reconstruction. Lab work at that time showed white blood cell count of 8.56 (normal limits 3.98–10.04 K/uL). Cardiothoracic surgery felt that this was a fistulous connection from the chest cavity rather than from the skin based on physical exam. The mesh was presumed infected and subsequently partially removed along with excision of the fistulous tract in May 2023. Bacterial cultures including anerobic cultures from both the fistula and mesh did not reveal any microorganisms on Gram stain, but both eventually grew *B. bronchiseptica*. Antibiotic sensibility testing revealed sensitivities to meropenem, trimethoprim-sulfamethoxazole, levofloxacin, tobramycin, and ciprofloxacin with intermediate sensitivity to piperacillin-tazobactam. A repeat thoracotomy was required on post-operative day three with further removal of mesh, excision of the seventh rib, and thoracoplasty with placement of a chest tube. Biopsy of the seventh rib revealed acute osteomyelitis without metastatic carcinoma but it is unclear from the outside facility documentation if any of the surgical samples sent were bone cultures. She was initially prescribed oral azithromycin 500 mg for seven days with plans to remove the chest tube as an outpatient. At this point, the acute osteomyelitis was not addressed.

After completing her antimicrobial treatment, she developed worsening pain, fevers (temperature max 102 °F), and purulent drainage from the chest tube. Lab work showed white blood cell count of 10.75 (normal limits 3.98–10.04 K/uL), c-reactive protein of 16.13 (normal limits < 0.5 mg/dL), and sedimentation rate of > 130 (normal limits 0–30 MM/HR). Repeated aerobic and anerobic cultures from the chest tube re-demonstrated *B. bronchiseptica* without other microorganisms isolated. Chest Xray showed deformity of right hemithorax following surgical resection and long-term gas collection in the upper half of the distorted right hemithorax. The infectious diseases team was then consulted at this point and recommended six weeks of intravenous (IV) meropenem given concerns for polymicrobial infection that was not captured on cultures and for coverage of her acute osteomyelitis. After this period of IV antibiotics, she was also prescribed several courses of either oral levofloxacin 750 mg daily or trimethoprim-sulfamethoxazole 800-160 mg twice daily by separate outpatient providers as she was moving states given recurrent symptoms. After each antibiotic course, she reported brief symptomatic improvement but then symptoms quickly recurred.

After her move from the northeast United States to the southeast in September 2023, she developed an enlarging, tender mass along her right scapula. She noted an improvement in the lesion size with antibiotics obtained from various providers but after completion it subsequently worsened.

At this point, she presented to our facility for further evaluation. She was afebrile, normotensive, and in no acute respiratory distress. Decreased breath sounds were appreciated in the right upper lung field. Admission laboratory work was significant for a white blood cell count of 12.46 K/mm^3 (normal limits 4.8–10.8 K/μL) with a left shift, hemoglobin of 8.3 g/dL (normal limits 14–18 g/dL), and a normal lactate. Two sets of blood cultures did not grow any microorganisms. Her renal function and electrolytes were also within normal limits. Computed tomography (CT) imaging of the chest showed a right upper hemithorax thick-walled cavity felt to represent a chronic pleural collection with communication to a 6.6 × 3.5 cm chest wall gas-fluid collection resembling EN (Fig. 1).

The imaging also noted multiple bronchopulmonary fistulas from the right middle lobe lateral segment and another from the right lower lobe superior segment. Cardiothoracic surgery performed an incision and drainage and sent aerobic, anaerobic, and fungal cultures including from the wound. During the procedure, they noted air, purulent secretions, and minimal loculations. While awaiting the cultures to mature, she was placed on IV vancomycin 750 mg every 12 h, IV piperacillin-tazobactam 4.5 mg every 8 h, and oral azithromycin 250 mg

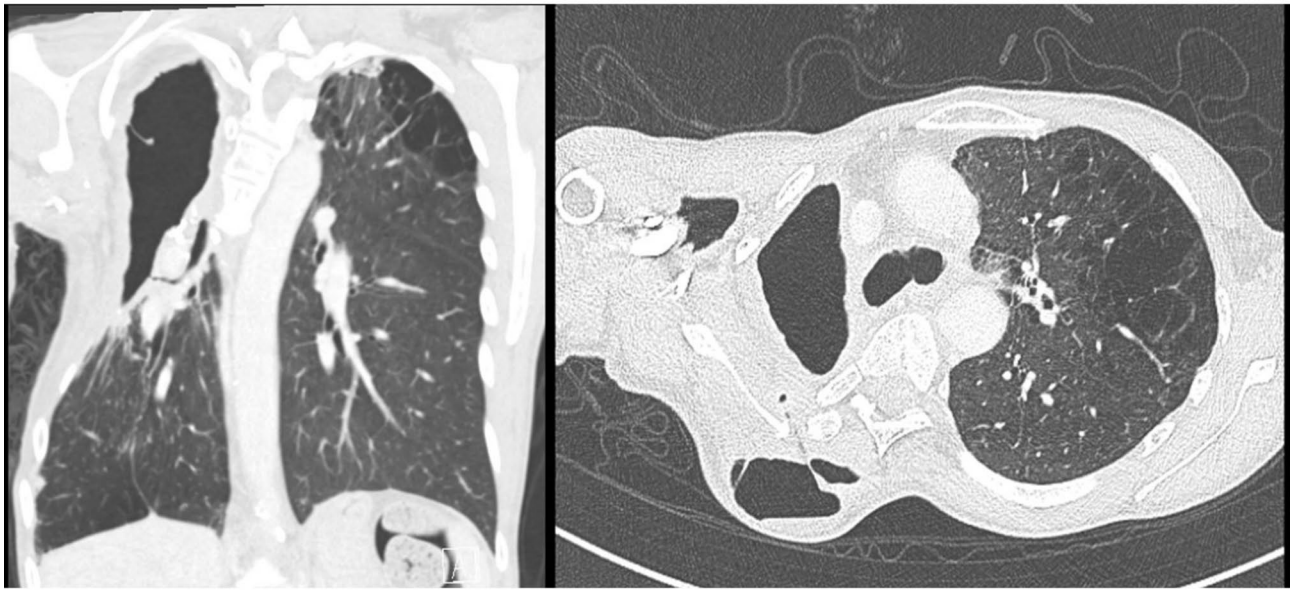

Fig. 1 CT chest with contrast: Coronal and transverse views of right upper hemithorax with thick-walled cavity representing a chronic pleural collection with communication to a 6.6 × 3.5 cm chest wall gas-fluid collection resembling empyema necessitans

daily for empiric coverage. The aerobic cultures returned with *B. bronchiseptica* and no other pathogens isolated on anerobic and fungal cultures. Identification of the culprit was done by Matrix-assisted laser desorption ionization-time of flight (MALDI-TOF) mass spectrometry. Susceptibilities on the sample were not performed given predictable susceptibility patterns within the genus. Ultimately, she was discharged with a six-week course of oral moxifloxacin 400 mg once daily to cover *B. bronchiseptica* as well as other potential pathogens that were not isolated including anerobes.

It was felt the recurrence of her empyema necessitans was secondary to lack of source control from her first surgical interventions. Subsequently, she underwent a Clagett window (Fig. 2) performed by cardiothoracic surgery, approximately one month into treatment, as an attempt to have definitive source control for her recalcitrant abscess.

Intra-operative findings included copious purulent drainage and mesh densely adhered to the thoracic outlet. She was discharged on post operative day 2 and continued on Moxifloxacin. Significant improvement in the amount of discharge was noted during infectious diseases clinic follow up after discharge. However, after completing her prescribed course, she again began to experience worsening cough and drainage. Her moxifloxacin course was extended for an additional 6 weeks. 2 months later after completion of Moxifloxacin she had recurrent symptoms, and aerobic and anerobic cultures was obtained of the Clagett opening upon re-hospitalization. This grew *Pseudomonas aeruginosa* only and she was prescribed oral ciprofloxacin 750 mg twice daily despite intermediate susceptibility (via Kirby-Bauer disc diffusion) given clinical improvement and desire to avoid IV therapy. The isolate was also susceptible to cefepime, piperacillin-tazobactam, meropenem, and amikacin. This was proposed to be a superimposed bacterial surgical site infection. On follow up, she endorsed significant improvement in her functional status towards the end of that course. As she has had a difficult course with recurrent disease, she will likely need to adopt preventative measures including avoiding further exposures to foster dogs and wearing personal protective equipment (PPE) consisting of gown, eye protection and surgical mask around dogs with unknown infectious status given the highly contagious nature *of B. bronchiseptica*.

Discussion and conclusions

This case raises several questions about the role of *B. bronchiseptica* as a pathogen in human disease. *B. bronchiseptica* has long been identified as the most common cause of canine infectious respiratory disease complex (CIRDC), or "kennel cough." This is highly contagious respiratory illness affecting dogs and cats. It is also thought to be a possible pathogen in atrophic rhinitis in swine [3, 6, 8]. Rarely, *B. bronchiseptica* has been isolated in humans with respiratory illness, and only a few of those cases had identifiable contact between humans and animals with respiratory illness [6, 7, 9]. In our case, our patient has known exposure to dogs with kennel cough as she has spent many years fostering dogs, including those diagnosed with kennel cough. Our patient had first noted a cutaneous lesion that had initially improved with oral antibiotics but then progressed to include a productive

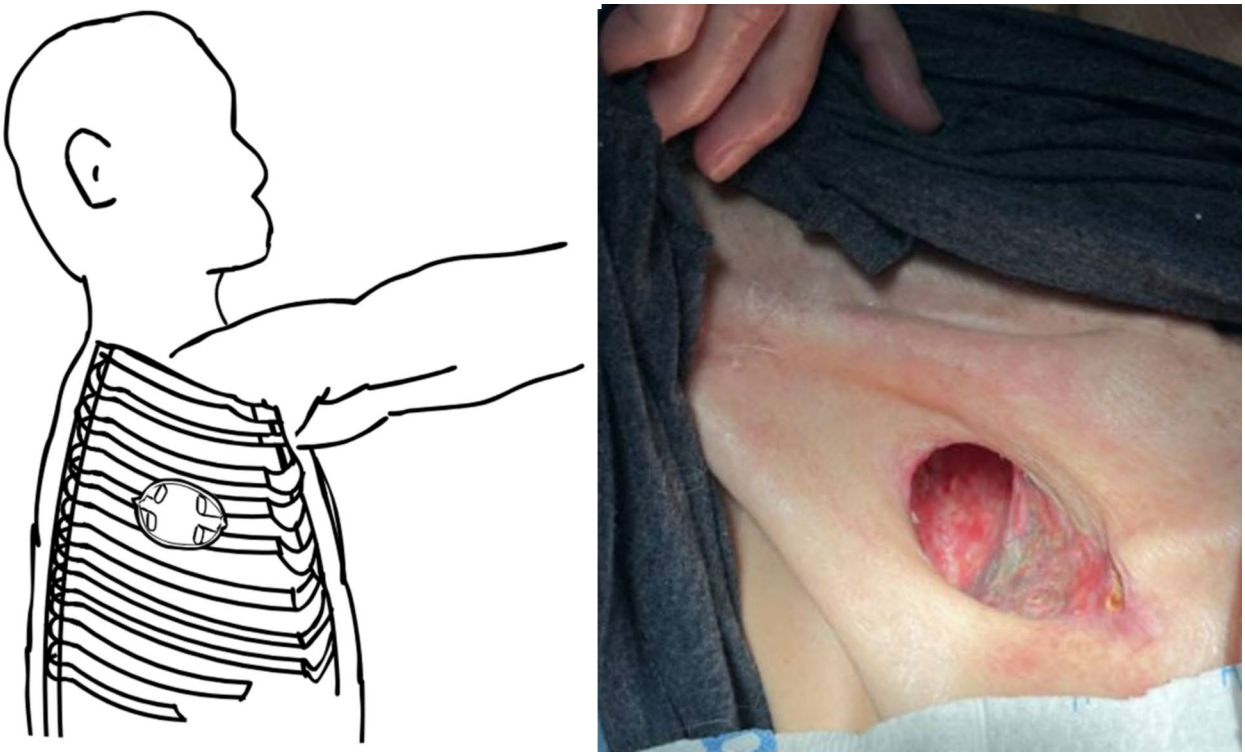

Fig. 2 Left: illustration of Clagett window demonstrating rib resection and resultant thoracostoma area. Right: postoperative picture of patient's Clagett window

cough and chest fullness. It is likely that the initial lesion was a late manifestation of a respiratory infection given the extent of imaging findings. The repeated exposure to the fostered dogs is likely the cause of her inoculation with *B. bronchiseptica*, contributing to the unusual complication of a recurrent EN. This is made evident by the persistence of her radiographic changes from May 2023 through February 2024. It is possible that the reason for treatment failure up to this point is lack of adequate source control as the susceptibility profile for the bacteria was favorable to several agents and she had symptom resolution while on highly bioavailable antibiotics. Her relapses did not occur until after completion of antibiotics, regardless of length of therapy, which further supports this theory. While presumed to be immunocompetent, our patient had received chemotherapy over 10 years prior and in theory could have some degree of impaired immunity. However, her prior radiation, lobectomy, and chest wall resection with subsequent mesh placement likely predisposed her to EN.

There have only been a few other reported cases of curious infections with *B. bronchiseptica* isolated through culture. A published report in 1979 showed a 73-year-old male with alcoholic malnutrition who was found to have bilateral pneumonia complicated by a right lung abscess and bacteremia. Bronchoscopic and tracheal aspiration cultures grew mixed aerobic and anaerobic bacteria, including *B. bronchocanis* (another name for *B. bronchiseptica*); one blood culture also demonstrated *B. bronchocanis* [6]. He was described as one who lived alone in a "slum" without mention of animal contact. A review of *B. bronchiseptica* infection and colonization over a 15-year period noted eight confirmed cases. Out of these eight, a 65-year-old male with underlying peripheral neutropenia was admitted for pneumonia and associated abscess with sputum cultures that demonstrated *B. bronchiseptica*. It is unclear if there were additional pathogens isolated from the sputum culture as well as if the abscess was aspirated to confirm the culprit pathogen [10]. Additionally, there was a case of a 71-year-old male who presented to the hospital for alcoholic hepatitis with a peripancreatic fluid collection incidentally noted on CT scan. The fluid collection was drained and *Klebsiella pneumoniae* and *B. bronchiseptica* were isolated [5]. As an obligate aerobe, it is unusual to have been isolated from a peripancreatic abscess. These were the only cases in where an abscess demonstrated *B. bronchiseptica* in humans as reviewed from PubMed, MedlinePlus, and GoogleScholar. Other important reports for *B. bronchiseptica* infection are notable for bacteremia and pneumonia without abscess formation.

The *Bordetella* genus causes a myriad of disease states in humans and animals and is highly dependent on which species of *Bordetella* infects which host. Similar to

our case, *B. hinzii* had been isolated in a subcutaneous abscess in an immunocompetent host [11]. *B. pertussis* is the culprit organism behind whooping cough in humans as well as a similar respiratory illness in primates with close contact to humans. Because the genus *Bordetella* has been implicated in many different disease states, it is difficult to identify the true pathogenicity of each species, especially in humans.

This case underscores the need for a deeper understanding of zoonotic infections and their pathogenic potential. We are continuing to identify disease culprits in humans classically thought to be exclusively animal pathogens. It is important to keep in mind as humans continue to expand into the natural world, closing the gap between animals and humans. A social history encapsulating review of animal exposures is paramount in identifying these novel infections. Furthermore, EN as a consequence of repeated animal exposure is an unusual complication that had yet to be seen with this microorganism.

This case presents public health implications for those that work closely with canines. Further research is needed to determine when PPE is needed for those with high degree of exposure to unvaccinated dogs, are immunocompromised, or have baseline structural lung disease. Guidance currently exists for veterinarians and kennels regarding confirmed cases, but more information is needed for prevention outside of vaccination.

LIST OF ABBREVIATIONS: Canine infectious respiratory disease complex (CIRDC); Computed tomography (CT); Empyema necessitans (EN); Intravenous (IV); Operating room (OR); Primary care provider (PCP), Personal protective equipment (PPE).

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None.

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S.W. contributed to the bulk of the manuscript writing and assisted with edits. N.R.T. contributed to the bulk of the manuscript writing and provided critical edits. R.L. provided critical edits and mentorship. All authors reviewed the manuscript.

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Data availability
The data supporting this study's findings are available from the corresponding author upon reasonable request and is provided within the manuscript.

Declarations

Ethics approval and consent to participate
Not-applicable.

Consent for publication
Written informed consent was obtained from the patient for publication of this case report and accompanying images. A copy of the written consent is available for review by the Editor-in-Chief of this journal on request.

Competing interests
The authors declare no competing interests.

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Publisher's note