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# *Bordetella* Infections in Dogs and Cats: Pathogenesis, Clinical Signs, and Diagnosis\*

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## KEY FACTS

- *Bordetella bronchiseptica* has a variety of pathogenic mechanisms that can make treatment and eradication difficult.
- Dogs typically have a mild, self-limiting cough, whereas cats may show other signs of respiratory disease.
- Although bordetellosis is a common cause of respiratory disease, definitive diagnosis requires a positive culture.

**ABSTRACT:** *Bordetella bronchiseptica* is a common cause of respiratory infection in dogs and cats. The disease has a high morbidity but low mortality and is diagnosed in individual pets as well as in group situations, such as boarding kennels and breeding facilities. *Bordetella* organisms have several pathogenic properties that result in clinical signs of respiratory tract disease. Diagnosis of bordetellosis is often based on the history and physical examination findings, but bacterial isolation and ancillary tests are also useful.

*Bordetella bronchiseptica* has been associated with infectious respiratory disease in dogs, cats, pigs, horses, rabbits, laboratory rodents, and humans for many years.<sup>1</sup> The main clinical sign in dogs is coughing, whereas cats may display nonspecific signs of upper respiratory infection. Despite the widespread availability of *Bordetella* vaccines, the disease is still commonly seen, especially in boarding kennels, shelters, research facilities, and veterinary clinics.<sup>2</sup> This article reviews information about *B. bronchiseptica* and provides a description of common clinical signs and diagnostic tests. Other infectious causes of coughing and upper respiratory disease (e.g., canine parainfluenza virus and adenovirus, feline herpesvirus and calicivirus) have been reviewed elsewhere.<sup>3,4</sup>

## ETIOPATHOGENESIS

In 1910, Ferry described a bacterial organism recovered from the trachea and bronchi of dogs with distemper.<sup>5</sup> In subsequent reports, he designated it *Bacillus bronchicanis*,<sup>6</sup> but when the organism was found to infect other animals, such as rabbits and guinea pigs, Ferry changed the name to *Bacillus bronchisepticus*.<sup>7</sup> Later, the organism was placed in the genus *Bordetella* along with other pathogenic species<sup>8,9</sup> (Table 1). Although Ferry was mistaken in assuming that the organism caused canine distemper, his work laid the foundation for later studies linking bacteria with infectious tracheobronchitis.<sup>10</sup>

*B. bronchiseptica* is a small gram-negative rod with a coccobacillary appearance. It grows on MacConkey's agar and other media and is strictly aerobic,

\*A companion article appears on p. 902.

motile, catalase-positive, and oxidase-positive.<sup>8</sup> Isolation of the organism from clinical specimens may be enhanced by the use of Schaedler's enrichment broth, charcoal blood agar with cephalixin, and extended incubation times.<sup>2</sup> *B. bronchiseptica* has been found to survive in natural environments such as lake water but is considered susceptible to routine cleaners and disinfectants, including household bleach diluted 1:32 with water.<sup>1,2,11,12</sup>

In both dogs and cats, *Bordetella* colonizes the respiratory tract and is not typically isolated from other tissues.<sup>3</sup> A recent case report identified *Bordetella avium*-like organisms from a dog with acute endocarditis.<sup>13</sup> Transmission occurs mainly through aerosolization of the organism from affected animals, but **contaminated fomites may also serve as a source of infection.**<sup>12</sup> The following are distinct properties and virulence factors of *B. bronchiseptica* that help explain the pathogenicity and clinical signs of disease.<sup>2</sup>

### Antigenic Modulation

In response to environmental signals, such as temperature, the *Bordetella* virulence gene transduction system mediates a switch among virulent, intermediate, and avirulent phases.<sup>14,15</sup> Virulent bacteria are able to use a type III secretion system, which delivers bacterial proteins to the cytosol via integrins (transmembrane proteins found in host cells).<sup>2,12,16</sup> This may allow the organisms to avoid complement-mediated destruction and the oxidative burst used by phagocytes.<sup>12</sup>

### Adhesins

*B. bronchiseptica* contains adhesins, which are protein structures that mediate attachment to specific receptors in the respiratory tract. Both fimbrial and nonfimbrial adhesins are found in various isolates<sup>2,9</sup>:

- **Fimbrial**—Fimbriae are hair-like appendages that extend from the bacterial cell membranes to host tissues.<sup>2</sup> They help in recognizing both target cells of the ciliated respiratory tract epithelium and host species specificity.<sup>2,17,18</sup> Also, *Bordetella* may have flagella that are involved in adherence to cells.<sup>18</sup>
- **Nonfimbrial**—Other proteins in the outer membrane of the bacteria facilitate colonization. Filamentous hemagglutinin helps in binding to cilia.<sup>2,9,19,20</sup>

**Table 1. Diseases in Animals Associated with *Bordetella***

<i>Bordetella</i> sp.	Host	Disease Conditions
<i>B. bronchiseptica</i>	Dogs	Infectious tracheobronchitis
	Cats	Respiratory infections
	Pigs	Atrophic rhinitis
	Horses	Respiratory infections
	Rabbits	Respiratory infections
	Rodents	Bronchopneumonia
<i>B. avium</i>	Poultry	Coryza
<i>B. parapertussis</i>	Sheep	Pneumonia
	Humans	Mild respiratory infections
<i>B. pertussis</i>	Humans, primates	Whooping cough
<i>B. holmesii</i>	Humans	Bacteremia
<i>B. hinzii</i>	Humans	Bacteremia

Pertactin is involved in binding directly to host cells.<sup>2,9,21</sup> These two proteins are used in human acellular *Bordetella pertussis* (whooping cough) vaccines and in the future may play a role in animal vaccination strategies.<sup>2</sup>

### Endotoxin and Exotoxin

The cell wall of *B. bronchiseptica* contains lipopolysaccharide or endotoxin, which stimulates cytokine release.<sup>8,9</sup> The role of lipopolysaccharide in infections is not well defined but probably involves colonization of the respiratory tract and protection against antimicrobials.<sup>22,23</sup> The following exotoxins may be produced by the bacteria<sup>2,9</sup>:

- **Tracheal cytotoxin**—This protein disrupts ciliated cells both by direct cell killing and by inhibition of ciliary function.<sup>12,24</sup>
- **Dermonecrotic toxin**—The role of dermonecrotic toxin is uncertain, but this toxin has been found to damage tissues and suppress both humoral antibody response to infection and cell-mediated immunity.<sup>12,25</sup>
- **Adenylate cyclase-hemolysin**—This enzyme inhibits the phagocytic function of neutrophils and macrophages by increasing the intracellular concentration of cAMP.<sup>12,26</sup>

### CLINICAL SIGNS

Experimental studies and field reports of *B. bronchiseptica* infection in dogs describe a dry, hacking (or honking), paroxysmal cough as the characteristic clinical sign.<sup>27,28</sup> **Coughing may appear worse with excitement and exercise and is often elicited by palpation of the laryngeal or tracheal regions.** Other signs that may

be seen in affected dogs are nasal discharge, gagging, retching, anorexia, depression, and fever.<sup>29-32</sup>

Cats affected with *B. bronchiseptica* typically show signs of upper respiratory disease.<sup>33</sup> Experimental inoculation of kittens resulted in sneezing, serous ocular and nasal discharge, coughing, dry or wet rales on auscultation, fever, lethargy, and mandibular lymphadenopathy.<sup>34-37</sup> Natural infections and reports from disease outbreaks in kittens and cats also describe signs of conjunctivitis, ocular discharge, bronchopneumonia, and death.<sup>38-43</sup>

The incubation period after experimental aerosol infection in dogs is reported to be 36 hours to 10 days.<sup>27,44-52</sup> This wide range likely reflects different strains of *B. bronchiseptica* as well as variations in experimental protocols. A survey of practitioners in the United Kingdom revealed a mean incubation period of 6.5 days with a range of 2 to 14 days in dogs presumptively affected with bordetellosis.<sup>32</sup> The duration of clinical signs may be as short as 1 to 2 days or up to several weeks.<sup>27,44-49</sup> In cats, the experimental incubation period is 2 to 6 days with a disease duration of 7 to 10 days.<sup>34,35</sup> Research studies demonstrated that *B. bronchiseptica* was recovered for 14 weeks from dogs and 19 weeks from cats, even after clinical signs had resolved, which demonstrates the persistence of the organism and a possible carrier state.<sup>31,35</sup>

In animals that are immunosuppressed or have concurrent infections with other bacteria or viruses, the disease may progress to bronchopneumonia and death. Other risk factors for more severe illness include chronic lung diseases such as bronchitis, ciliary dyskinesia, and hypoplastic or collapsing trachea.<sup>12,40,41,53,54</sup>

## DIAGNOSIS

A combination of history, examination, and clinical signs can strongly suggest infectious tracheobronchitis in dogs, with *B. bronchiseptica* being the most common bacterial cause.<sup>2,12,54</sup> Recent exposure to other dogs in a boarding kennel, dog show, public area, or veterinary clinic is a typical historical finding.<sup>3</sup> In uncomplicated cases, owners report normal activity levels and appetites despite the coughing, which is often described as choking or sounding like "a bone caught in the throat."<sup>12,55</sup> The physical examination may be unremarkable except for coughing elicited on tracheal palpation.<sup>3,12</sup>

Cats presenting with signs of upper respiratory disease are usually infected with rhinotracheitis (herpesvirus), calicivirus, or *Chlamydomphila felis* rather than *B. bronchiseptica*.<sup>56</sup> Risk factors for feline bordetellosis include the environment (rescue catteries, multicat households), exposure to dogs with respiratory disease,

and concurrent respiratory infections.<sup>57</sup>

Dogs and cats that show signs of bordetellosis along with fever, lethargy, anorexia, respiratory distress, or other systemic signs should receive a diagnostic evaluation.<sup>12,54</sup> A complete blood cell count, chemistry profile, urinalysis, heartworm test, and thoracic radiography will help screen for other disorders. In experimental infections of dogs, the only abnormal findings on blood tests were neutrophilia with a left shift and monocytosis.<sup>49,52</sup> Neutrophilia has also been reported in affected cats.<sup>41</sup>

Definitive diagnosis of *B. bronchiseptica* infection requires a positive culture obtained from nasal swabs, oropharyngeal swabs, or tracheal washes.<sup>8</sup> Culture results may be difficult to interpret, especially if samples are taken from the nose or throat where mixed flora are often found in both healthy and diseased animals.<sup>2,12</sup> Positive *B. bronchiseptica* cultures obtained from the trachea, using sterile techniques such as guarded swabs through sterile endotracheal tubes or bronchoalveolar lavage, are significant.<sup>2</sup> The diagnostic laboratory should be informed of the possibility of *B. bronchiseptica* infection so that special isolation techniques and quantitation can be performed.<sup>2,8</sup> Cytology and Gram's stain should also be conducted on specimens obtained for culture. A neutrophilic inflammatory response with intracellular bacteria suggests bordetellosis, although other types of bacteria and agents, such as mycoplasma, viruses, protozoa, or fungi, may result in cytologic evidence of inflammation.<sup>2,12</sup>

In clinical practice, pursuing an exact etiology for signs of tracheobronchitis in dogs or upper respiratory disease in cats is rarely necessary.<sup>54,58</sup> Because several bacterial organisms and viruses may be involved, a thorough investigation includes culture, viral isolation, and possibly serology to detect antibody titers to the various agents.<sup>52,59</sup> Disease outbreaks in areas such as animal shelters, kennels, catteries, or research facilities may require a complete diagnostic workup to identify specific causes and determine therapeutic options and preventive measures.<sup>12,60</sup>

## SUMMARY

*B. bronchiseptica* has been a recognized pathogen in animals for many years. Recent research has characterized some of the properties that help explain the organism's virulence and the associated clinical signs. Although most affected dogs and cats have a mild, self-limiting illness, more severe infections may result in bronchopneumonia and death. If systemic signs are present, a complete diagnostic workup, including bacterial culture, is recommended to help with treatment decisions.

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The article you have read qualifies for 1.5 contact hours of Continuing Education Credit from the Auburn University College of Veterinary Medicine. Choose the best answer to each of the following questions; then mark your answers on the postage-paid envelope inserted in *Compendium*.

1. Which of the following are characteristics of *B. bronchiseptica*?
  - a. gram-positive coccobacillus, motile, aerobic
  - b. gram-negative rod, nonmotile, anaerobic
  - c. gram-positive coccus, nonmotile, aerobic
  - d. gram-negative rod, motile, aerobic
2. Which statement concerning pathogenic mechanisms of *B. bronchiseptica* is true?
  - a. The *Bordetella* virulence gene transduction system is found only in virulent isolates.
  - b. Adenylate cyclase-hemolysin is an exotoxin that inhibits ciliary function.
  - c. Nonfimbrial adhesins, such as filamentous hemagglutinin and pertactin, are involved in bacterial attachment to host cells.
  - d. Tracheal cytotoxin and dermonecrotic toxin are part of the cell wall endotoxin complex.
3. Bordetellosis in dogs is characterized by
  - a. paroxysmal coughing.
  - b. sneezing.
  - c. collapsing trachea.
  - d. interstitial pneumonia.
4. Which clinical sign is not found in cats affected with *B. bronchiseptica*?
  - a. coughing
  - b. conjunctivitis
  - c. sneezing
  - d. oral ulceration
5. *Bordetella* organisms have been cultured from dogs for as long as \_\_\_\_\_ weeks after infection.
 

a. 3	c. 19
b. 14	d. 26
6. In cats, the clinical signs of bordetellosis usually last approximately \_\_\_\_\_ days.
  - a. 1 to 2
  - b. 3 to 7
  - c. 7 to 10
  - d. 10 to 21

7. Which of the following is not a risk factor for more severe illness associated with *B. bronchiseptica* in dogs?
  - a. chronic bronchitis
  - b. ciliary dyskinesia
  - c. hypoplastic trachea
  - d. laryngeal paralysis
  
8. Bordetellosis is best diagnosed by history, clinical signs, and
  - a. cytology and culture of tracheal wash.
  - b. cough elicited on tracheal palpation.
  - c. cytology and Gram's stain of conjunctival swabs.
  - d. measuring antibody titers.
  
9. Which test(s) is/are not needed for dogs and cats with signs of bordetellosis that also have fever, lethargy, or respiratory distress?
  - a. abdominal radiography and ultrasonography
  - b. complete blood cell count and chemistry profile
  - c. thoracic radiography
  - d. heartworm testing
  
10. Which is the best method of isolating *Bordetella* from an affected dog or cat?
  - a. conjunctival swab
  - b. nasal swab
  - c. tracheal swab
  - d. lung aspirate