**Bordetella bronchiseptica** and canine influenza virus (CIV) are common causes of infectious tracheobronchitis and, occasionally, pneumonia. Combined, these and other pathogens cause the canine infectious respiratory disease complex (CIRDC), often referred to as *kennel cough* or *infectious tracheobronchitis*. The multitude of bacterial and viral organisms associated with CIRDC are listed in Table 1.

In general, morbidity for CIRDC is high with mortality being low. Severe cases can result in life-threatening respiratory compromise due to pneumonia.

### DISEASE PROFILE

**Bordetella bronchiseptica**

*B. bronchiseptica*, a primary respiratory pathogen, is a gram-negative, aerobic coccobacillus that is often implicated as a complicating factor in dogs with concurrent viral respiratory infections.  

**Virulence Factors.** After *B. bronchiseptica* colonizes the airways, it can evade the immune system by expressing various virulence factors that lead to:  
- Direct cellular injury of respiratory epithelium  
- Impaired immune recognition  
- Disrupted immune clearance.

Perhaps one of the most unique and important effects of these virulence factors is the ability to paralyze the mucociliary apparatus—a key component of the respiratory tract’s local defense mechanisms—and create acquired ciliary dysfunction.  

The mucociliary apparatus moves inhaled debris and opportunistic pathogens away from the lower respiratory tract, decreasing the risk of colonization by these organisms and the potential for associated pneumonia. By paralyzing the cilia, *B. bronchiseptica* not only improves its own virulence and chance for colonization, but also predisposes the patient to opportunistic infections of the lower respiratory tract.

**Disease Spectrum.** The spectrum of disease that results from infection with *B. bronchiseptica* is wide, with some dogs manifesting mild disease characterized by nasal discharge and intermittent cough and others developing severe pneumonia that can be life threatening.

**Canine Influenza Virus**

CIV (H3N8) is most closely related to equine influenza virus, which suggests that a direct transmission from horses to dogs occurred. CIV was first detected in racing greyhounds in Florida, and since has become more prevalent among pet dogs, especially those in kennels, shelters, and multidog households.

**Prevalence.** The prevalence of serum antibodies against CIV in dogs with no clinical signs of respiratory disease has been shown to be 0.5% to 3%, depending on the risk of the population being evaluated (Figure 1).
Bordetella Bronchiseptica & Canine Influenza Virus (H3N8)

Note that a positive antibody titer in a population of dogs with no signs of respiratory disease likely indicates prior exposure to the virus, rather than active infection.

In shelter dogs with signs of respiratory disease, seroprevalence is as high as 50%, depending on length of time since intake to the shelter.11,12 Given the population, these patients are likely co-infected with other common viral and bacterial pathogens that encompass the CIRDC (Table 1).

However, veterinarians should recognize that the prevalence of CIV is much lower in client-owned dogs with respiratory signs, especially if they have not been recently exposed in a shelter or boarding kennel.

Geographic Location. CIV is associated with geographic hot spots, and practitioners should become familiar with the particular areas in which it has been identified. In a recent study, seroprevalence of CIV in dogs with influenza-like illness was highest in the northeast, west, and southwest United States, with the highest representation being in New York, Colorado, and Florida.7

RISK FACTORS

Both CIV and B bronchiseptica infections are highly contagious, and dogs of any age and breed may become infected. Those at most risk for exposure and infection include:

- Dogs housed in boarding facilities, shelters, kennels, and pet shops8,9
- Puppies, especially those in the above housing situations, due to reduced immunity (both local and systemic), which may result in severe infection and death.9

Factors that contribute to risk and severity of infection in puppies include:

- Close contact with other dogs and puppies
- Immature immune systems
- Immune dysfunction due to concurrent infections (viral, bacterial, parasitic).

Because puppies housed in shelters and pet shops are often in closed ventilation spaces with other puppies from various environments, they are at highest risk.

PREVENTION

Vaccination can help protect against infection and reduce severity of clinical disease. Turn to page 72 to read Dr. Richard Ford’s article, Kennel Cough Revisited, for a discussion on current advances in vaccination for canine respiratory disease.

TRANSMISSION

Mode of Transmission

Transmission of B bronchiseptica and CIV occurs via:1

- Oronasal contact with other dogs, caregivers, or fomites
- Inhalation of aerosolized microdroplets of respiratory secretions.

In high-density housing situations, direct contact among dogs is most common. Less commonly, fomites serve as a source of transmission.

CONSIDERATIONS IN HOSPITAL

Considering modes of transmission and environmental survival of the agent is important when discussing management of patients in hospital. Clinicians should take precautions when handling these patients and make efforts to limit exposure throughout the hospital.

- Hospitalize patients in isolation facilities within the clinic to limit exposure to other dogs, especially those that are immunocompromised. As much as possible, manage infected patients as outpatients.
- Ensure that staff wear protective clothing, such as gloves and disposable gowns, when working with infectious patients.
- Keep the veterinary team from handling other patients of the same species during the same shift in which they have handled infectious patients.
- Limit contact between critical patients that require oxygen therapy and close monitoring— who are not candidates for an isolation area—and other patients in the critical care unit.
- Implement precautions to limit fomite contamination.

An in-depth review of preventing CIV in the hospital setting is presented in the article Is Your Practice Proactive or Reactive? (January/February 2012), available at tvpjournal.com (Article Library).

Figure 1. Map of canine influenza cases, including all CIV positives between 2007 and 2014 (207 positives). Individual pins may represent multiple cases. Courtesy IDEXX Laboratories
Shedding & Survival
Most viruses begin shedding within 2 days post infection, and may continue to shed for 6 to 10 days before viral load decreases. B bronchiseptica can survive in the environment for extended periods of time, and can be shed from dogs that appear healthy because it has the ability to elude the immune system for weeks to months.

INITIAL DIAGNOSIS
Although definitive diagnosis is pursued in some cases, a suspected clinical diagnosis can often be made based on:
- Clinical signs
- Assessment of risk/exposure
- Response to appropriate treatment.

Clinical Presentation
Clinical presentation varies among individual cases of B bronchiseptica and CIV infections, based on severity and concurrent bacterial and/or viral pathogens involved. Clinical signs include:
- Acute onset of a nonproductive cough (most common clinical sign)
- Serous or mucopurulent nasal and/or ocular discharge
- Sneezing
- Tachypnea, respiratory distress, systemic illness, and fever (more severe cases).

Thoracic Radiographs
Thoracic radiographs may support a diagnosis of B bronchiseptica or CIV (Table 2) but, more important, help to rule out other causes of acute cough.

Thoracic radiographs are recommended for any patient with:
- Persistent (> 1–2 weeks) or worsening cough
- Respiratory distress
- Signs of systemic illness (eg, lethargy, decreased appetite).

In more severe cases, radiographs are necessary to evaluate if pneumonia is present. Thoracic radiographs are not typically indicated in otherwise healthy patients with acute onset of only coughing (no signs of respiratory distress, tachypnea, fever, or systemic illness).

Laboratory Analysis
In complicated cases, a complete blood count and serum biochemical profile should be performed to assess systemic health, but these diagnostics are not generally necessary for diagnosis of B bronchiseptica or CIV.

<table>
<thead>
<tr>
<th>TYPE OF INFECTION</th>
<th>RADIOGRAPHIC APPEARANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uncomplicated B bronchiseptica or CIV (confined to upper respiratory tract)</td>
<td>Normal thoracic radiographs</td>
</tr>
<tr>
<td></td>
<td>Narrow tracheal lumen, creating a hypoplastic appearance due to tracheal mucosal edema</td>
</tr>
<tr>
<td>Complicated B bronchiseptica or CIV (lower respiratory tract involvement)</td>
<td>Heavy interstitial, bronchial, or alveolar lung pattern (Figure 2)</td>
</tr>
<tr>
<td></td>
<td>With CIV, diffuse or patchy interstitial or alveolar lung pattern consistent with pneumonia</td>
</tr>
</tbody>
</table>

Figure 2. Radiographs from a 7-month-old basset hound puppy with Bordetella bronchiseptica pneumonia; note the diffuse heavy interstitial to alveolar lung pattern, which is most severe on the left side.
DEFINITIVE DIAGNOSIS

**Bordetella bronchiseptica**

Definitive diagnosis of *B bronchiseptica* is based on isolation of the pathogen from aerobic culture of respiratory secretions.

**Sample Collection.** For cytology and culture of bacteria, obtain airway samples via:

- Transtracheal or endotracheal wash
- Bronchoalveolar lavage (blind or bronchoscopy-guided).

Patients with unresponsive focal pneumonia may require bronchoscopy-guided bronchoalveolar lavage fluid collection to obtain a sample that accurately represents the causative pathogen.

Nasal, oral, oropharyngeal, and nasopharyngeal bacterial cultures are *not* recommended, as they yield growth of normal respiratory flora, making it difficult to determine the primary pathogen causing disease. In addition, deep oral swabs are *not* recommended in puppies with community-acquired pneumonia.

*Mycoplasma* species cannot be seen on cytology and are difficult to culture; consider submitting a mycoplasma polymerase chain reaction (PCR) or mycoplasma culture, when indicated.

**Sample Preparation.** Following collection of an airway sample, cytology should be performed as quickly as possible (ideally within hours) to reduce disruption of the cells. Because many samples are fairly low in cellularity, a concentrated population of representative cells can be evaluated by a cytopsin or line smear preparation or manual smearing of pelleted cells.

If the clinician is planning to send the sample to a clinical pathologist for evaluation, the sample should be stored at 4°C and shipped overnight (ideally processed within 24 hours after collection).

**Sample Evaluation.** Evaluate the sample for the differential cell count and presence of bacteria or other infectious organisms. *B bronchiseptica* has a characteristic cytologic appearance, with the coccobacilli adhering to respiratory epithelial cells (Figure 3).

**Canine Influenza Virus**

Definitive diagnosis of CIV is based on real-time PCR (RT-PCR) identification of CIV from respiratory secretions. RT-PCR (nasal or pharyngeal swabs) has replaced viral isolation via tissue culture or serology due to:

- Difficulty in obtaining samples for culture antemortem
- Concerns about previous exposure clouding results of serologic testing.

Definitive diagnosis is a challenge in some patients because viral shedding declines within approximately 7 to 10 days post exposure, often prior to onset of clinical signs, resulting in a false–negative RT-PCR.

ANTIMICROBIAL THERAPY

Antimicrobial therapy can be important in patients with suspected *B bronchiseptica* infections or, if CIV or another viral respiratory pathogen is suspected, to treat secondary bacterial infections.

**Doxycycline**

Doxycycline (5 mg/kg PO Q 12 H or 10 mg/kg PO Q 24 H) is my treatment of choice for *B bronchiseptica* and most infectious respiratory diseases.

**Enamel Discoloration.** Clinicians are often concerned about using doxycycline in young patients due to its potential to discolor enamel of developing teeth; however, it is less likely to cause discoloration compared to other tetracycline antibiotics. Limiting treatment to <10 days further reduces the risk.

**Doxycycline Resistance.** Some isolates of *B bronchiseptica* are doxycycline-resistant, and patients may require treatment with a fluorquinolone (enrofloxacin or marbofloxacin), azithromycin, or chloramphenicol; however, management of these patients should ideally be based on culture and susceptibility of airway samples.

**Other Tetracyclines**

The current shortage of doxycycline has dramatically increased its cost; therefore, it is a less desirable option for owners with financial concerns. Most clinicians are using other tetracycline drugs, such as minocycline, in place of doxycycline for treatment of tick-borne disease, but the pharmacokinetics of minocycline for various disease conditions in dogs is currently under investigation.

Dosing for treatment of bordetellosis is currently unknown; recommended treatment of methicillin-resistant staphylococcal infections is 5 mg/kg PO Q 12 H or 10 mg/kg PO Q 24 H.

**Other Antibiotics**

Other antibiotics to consider include:

- Azithromycin
- Fluoroquinolones
- Amoxicillin-clavulanate
- Cephalosporins.
MANAGING CRITICALLY ILL DOGS
When managing critically ill dogs with *B. bronchiseptica* and/or CiV, implement the following supportive therapy:

1. **Provide Increased Oxygen Concentrations**
   Severe cases of *B. bronchiseptica* and CiV may present in respiratory distress and require oxygen supplementation.
   
   - Assess oxygenation via pulse oximetry and/or arterial blood gas analysis. Pulse oximetry is noninvasive and available in most practices, but does not always provide an accurate measurement.
   - Provide oxygen supplementation to patients with:
     - SpO2 of 92% to 94% or PaO2 < 80 mm Hg, especially if signs of respiratory difficulty are present
     - Increase in respiratory effort, even if the patient is oxygenating appropriately.
   
   Common methods of oxygen supplementation in hospital include oxygen cage, tent, nasal cannula(s), and nasal prongs. Nasal cannula or prongs may work best for highly contagious patients that must be isolated, but require supervision to ensure the catheter does not become dislodged (Figure 4).

2. **Improve Clearance of Respiratory Secretions**
   Critical patients often lose fluids through the respiratory tract, especially if they are febrile, leading to increased viscosity of secretions and reduced ciliary clearance.
   
   - Initiate IV fluids to replace fluids lost and improve clearance of respiratory secretions.
   - Nebulization with sterile saline (6–10 mL) results in a liquid particulate suspension that improves clearance of tracheal and bronchial secretions. Nebulization followed by coupage may be performed for 15 to 20 minutes every 4 to 8 hours in hospitalized patients; owners may rent or purchase a handheld jet nebulizer for use at home.

3. **Treat Primary or Secondary Bacterial Pathogens**
   Antibiotic therapy is essentially the same for all patients (see ANTIMICROBIAL THERAPY); however, injectable antibiotics should be considered for critically ill patients, due to associated gastrointestinal upset and poor bioavailability of oral antibiotics in anorexic patients. Fluoroquinolones (enrofloxacin, ciprofloxacin) may be preferred for injection because, compared to doxycycline, they provide more broad spectrum coverage for gram-negative organisms, are unlikely to result in phlebitis, and are less expensive.

**Figure 4.** Dog with nasal cannula in place.

Note that tetracyclines and fluoroquinolones readily cross the blood–bronchus barrier, but penicillins and cephalosporins do not and, therefore, may be associated with treatment failure in some cases. Although fluoroquinolones are less desirable in young animals due to their effects on cartilage development, this risk may be of less concern in patients with life-threatening infections.16

**ADDITIONAL THERAPIES**

**Glucocorticoids & Cough Suppressants**
Anti-inflammatory glucocorticoids and/or cough suppressants may be indicated for patients with infectious
tracheobronchitis or suspected tracheitis secondary to frequent coughing. Ensure the patient has no evidence of pneumonia and is otherwise systemically healthy before intervening with these therapies.

Most patients with CIRDC do not require these therapies, and I do not recommend using oral/inhaled corticosteroids or cough suppressants in patients with moderate to severe *B bronchiseptica* infection or CIV, especially if pneumonia has developed.

Cough suppressants, in particular, are contraindicated in patients with bronchopneumonia, as suppression of cough can prevent clearance of bacteria, worsening disease, and/or delay recovery.

**Bronchodilators**

Methylxanthines (eg, theophylline, aminophylline) and beta-2 agonists are bronchodilators that prevent bronchospasm. There is evidence that methylxanthines improve ventilation and diaphragmatic contractility in dogs, which may result in improved PaCO₂ levels in severely affected puppies; however, there is no evidence of benefit in patients with uncomplicated CIRDC.²

If considering use of a bronchodilator in a patient with CIRDC, I prefer methylxanthines due to their other potentially beneficial effects, including anti-inflammatory properties, improved mucociliary clearance, and improved diaphragmatic contractility.² Unlike cats and humans, dogs do not develop true strong muscle bronchoconstriction, and therefore, beta-2-agonists are not useful in the management of canine respiratory disease.

In my opinion, bronchodilator therapy, while extremely important in management of feline lower airway disease, has limited value in canine respiratory disease and may have undesirable adverse effects (cardiac, gastrointestinal). Therefore, I do not recommend bronchodilators for treatment of infectious tracheobronchitis or pneumonia caused by *B bronchiseptica* or CIV.

**Expectorants**

Aerosolized or oral expectorant or mucolytic therapy is often instituted in cases of canine respiratory diseases that result in excessive tracheal and/or bronchial secretions. However, I do not recommend therapy with expectorants because:

- Nebulized N-acetylcysteine can be irritating and result in bronchospasm, further worsening tracheobronchitis and coughing.
- Guaiifenesin, an expectorant often paired with a cough suppressant, has no scientific or anecdotal (that I have observed) evidence supporting its use in patients with *B bronchiseptica* or CIV.

**Antiviral Agents**

The safety and efficacy of specific antiviral agents, such as neuroaminidase inhibitors (eg, oseltamivir phosphate, zanamivir) has not been evaluated in dogs.¹ Therefore, these agents cannot be recommended for dogs with CIV or other respiratory viral diseases.

**Intranasal Vaccines**

There are anecdotal reports promoting administration of the intranasal *B bronchiseptica* vaccine in dogs with CIRDC. However, to date, there are no controlled studies that support its use as a “therapeutic” intervention in dogs with *B bronchiseptica* infection or CIV and, in critical patients with this infection or virus, intranasal vaccine administration may worsen the course of disease because the immune system is already compromised, and an immune response places additional stress on the system.

CIRDC = canine infectious respiratory disease complex; CIV = canine influenza virus; PaCO₂ = arterial partial pressure of carbon dioxide; PaO₂ = arterial partial pressure of oxygen; PCR = polymerase chain reaction; RT-PCR = real-time PCR; SpO₂ = hemoglobin oxygenation saturation measured by pulse oximetry

References

4. Anderton TI, Masket DJ, Preston A. Ciliostasis is a key early event during colonization of canine tracheal tissue by *Bordetella bronchiseptica*. Microbiology 2004; 150:2843-2855.