Canine Respiratory Infections in Shelters

Overview

Contagious respiratory infections are the most common cause of illness in dogs in shelters. These infections represent a significant and frequent drain on shelter resources, including treatment costs, staff time, and staff morale. Holding dogs for treatment and recovery adds to the number of animal care days until adoption, which in turn impacts the housing capacity for the shelter and contributes to potential for crowding. Many shelters do not have adequate isolation areas to house dogs with contagious respiratory infections, so they are frequently kept in the general population, assuring the transmission and perpetuation of the pathogen so that it becomes an accepted "endemic" problem. In other words, respiratory infections are mostly accepted as a "fact of life" in shelters. However, some respiratory pathogens such canine distemper virus, canine pneumovirus, and canine influenza virus have resulted in temporary closure of numerous shelters and depopulation due to severity of disease or numbers of affected dogs. These situations not only impact animal health and welfare, but also attract unfavorable scrutiny by the media and community.

This document provides a basic overview of: 1) common canine respiratory pathogens in shelters, 2) incubation times, clinical disease, duration of pathogen shedding, modes of transmission; 3) diagnosis; and 4) strategies for management and prevention in shelters.

CIRD

Canine infectious respiratory disease (CIRD), commonly referred to as "kennel cough", is a multifactorial disease complex because the same clinical syndrome is caused by many different pathogens, including the following:

- Parainfluenza virus (CPiV)
- Adenovirus type 2 (CAV2)
- Distemper virus (CDV)
- Herpes virus (CHV)
- Influenza virus H3N8 (H3N8 CIV)
- Influenza virus H3N2 (H3N2 CIV)
- Respiratory coronavirus (CRCoV)
- Pneumovirus (CnPnV)
- *Bordetella bronchiseptica* bacteria (Bordetella)
- *Streptococcus zooepidemicus* bacteria (Strep zoo)
- *Mycoplasma cynos* bacteria (Mycoplasma)

While most of these pathogens can cause a primary infection, most dogs frequently have mixed viral and bacterial co-infections. Recent studies in the U.S. and Europe have provided evidence that ***viral pathogens are the more common primary cause of respiratory infections in dogs in shelters and co-infections with multiple viruses occur frequently.*** Viral replication damages the respiratory epithelium and mucociliary apparatus in the upper respiratory trac, providing opportunity for secondary

infections by commensal bacteria, such as *Mycoplasma* spp, *Pasteurella multocida*, *Klebsiella pneumoniae*, *E. coli, Staphyloccus spp, and Streptococcus spp.* that exacerbate the severity and duration of disease. Conversely, primary infection by bacteria such as *Bordetella* or *Mycoplasma,* both of which destroy ciliated epithelial cells, can predispose to viral infections.

Risk Factors for CIRD

CIRD is also complex because the intricate interplay between host, pathogen, and husbandry factors determines risk for infection.

Host Factors	Pathogen Factors	Husbandry Factors
Age (puppy vs. adult)	Virulence	Crowding
Immune status	Incubation period	Random co-mingling in runs
Debilitation	Shedding period	Ineffective sanitation
Stress	Subclinical infection	Poor ventilation
	Carrier state (persistent infection)	Chronic moisture
	Transmission routes	Stress
	Incomplete protection by vaccines	Untrained staff
	No vaccines for newer pathogens	Improper vaccination strategies

Host Factors

In general, puppies are more susceptible to infections than adult dogs because of their lack of natural immunity from prior exposure and ineffective responses to vaccination due to interference by maternally derived antibodies. They typically enter shelters at an age when maternal immunity has waned to a level that does not protect against infection, but still interferes with responses to vaccination. Unvaccinated adult dogs are also at greater risk for infection. Housing of puppies with adult dogs increases the risk for respiratory infections in the puppies since some pathogens result in inapparent disease in adults, but the infected adults are contagious. Puppies and adults that are debilitated by poor nutritional status, parasitism, infections with other pathogens, and stress from the shelter environment are more at risk for acquiring respiratory infections.

Pathogen Factors

Inherent properties of pathogens also affect the risk for infection. Virulence, length of incubation period, preclinical shedding, duration of shedding, routes of transmission, and persistence in the environment significantly influence infection risk. The ability to establish subclinical infection or persistent infection increases the infectious dose of the pathogen in the environment. Respiratory pathogens are notorious for spread by droplets and aerosols which increase the difficulty in stopping rapid transmission throughout the kennel. Available vaccines for some of the respiratory pathogens provide only partial protection in that the vaccine-induced antibodies do not prevent infection, but do ameliorate the severity of clinical disease. In addition, there are no vaccines for some of the newer pathogens such as canine respiratory coronavirus (CRCoV), canine pneumovirus (CnPnV), and *Strep zoo*.

Husbandry Factors

Most husbandry issues stem from ***ineffective population management and random co-mingling of unrelated dogs,*** resulting in exceeding the housing capacity of the facility, crowding of numerous dogs into each kennel, longer resident time in the shelter, and increased stress for the animals and staff. Crowding hampers effective cleaning and disinfection procedures, which increases the infectious dose of pathogens in the environment. Because of multiple dogs per run and no empty runs to facilitate cleaning/disinfection, cleaning may consist only of spraying kennel floors (and possibly dogs) with water to remove feces and urine, or tethering of dogs to adjoining occupied runs or housing in a common run while cleaning. Crowding also decreases ventilation and air quality which contributes to irritated airways, predisposing to colonization by pathogens. Studies have shown that ***risk for acquiring respiratory infections increases with every day of residence in the shelter.*** Lastly, staff members that are not trained to recognize respiratory infections and follow a plan for prompt removal of dogs from the general population to an isolation setting contribute to increased pathogen transmission and infectious dose in the environment.

Clinical and Epidemiological Features

All of the known canine viral and bacterial respiratory pathogens cause similar clinical signs: acute onset of cough, sneezing, nasal and ocular discharge (“kennel cough’). All of the pathogens also have the propensity to colonize the lower respiratory tract to cause pneumonia.

Bordetella, CAV2, and CPiV cause mild transient infections in most dogs. However, *Bordetella* can cause severe life-threatening pneumonia in puppies if not recognized and treated with appropriate antibiotics. In fact, *Bordetella* can establish chronic infection in untreated dogs resulting in intermittent relapses and bacterial shedding for up to 3 months.

CRCoV is usually associated with inapparent or mild transient disease and is a frequent co-pathogen with other respiratory viruses. Most dogs are susceptible to infection but a large number have subclinical infection. CRCoV is endemic in many high density/high turnover shelters where it is likely the most common cause of mild and transient respiratory illness.

H3N8 CIV, H3N2 CIV, and CnPnV cause an explosive increase in number of coughing dogs in a short period of time. Since most dogs are susceptible to infection, these viruses can cause epidemics in shelters. In addition, dogs infected with any of these viruses can develop high fever and pneumonia requiring advanced care in hospital settings. Compared to dogs in all settings, shelter dogs are the highest risk group for exposure to the influenza viruses and CnPnV.

Unlike the other respiratory pathogens, CDV infects multiple organ systems - respiratory tract, gastrointestinal tract, urogenital tract, ocular tract, nervous system, and skin. Infection of multiple systems confounds recognition and causes frequent misdiagnosis. The initial clinical signs are typical for kennel cough, but most infected dogs progress to pneumonia and a wasting syndrome. Other clinical signs include vomiting and diarrhea similar to parvovirus, dry eye, photophobia, pustular skin rashes, or development of seizures and myoclonus within 1-3 months. Some dogs develop hyperkeratosis of the nasal planum and footpads (“hardpad”).

Primary infection by canine herpesvirus (CHV) may be inapparent or cause mild respiratory signs such as sneezing and nasal discharge. Unlike the other viral respiratory pathogens, this virus establishes a lifelong infection that remains in a latent state unless viral replication is reactivated by stress. Reactivated infections are generally not associated with clinical signs but shed virus can be transmitted to other dogs by close contact.

Strep zoo is a Lancefield group C bacterium that has recently been identified in shelter dogs. The clinical disease starts with cough and nasal discharge, rapidly progresses to respiratory distress and bleeding from the respiratory tract, followed by death within hours. In many cases, the initial respiratory signs are so subtle that they are not noticed by staff and the infected dog is discovered dead in the run with blood oozing from the mouth and nose. Death is due to fulminant hemorrhagic pneumonia and hemothorax. The possibility of *Strep zoo* transmission in a shelter must be recognized quickly as survival depends upon prompt therapy with penicillin or cephalosporin antibiotics. *Strep zoo* has also been documented as a co-pathogen in dogs infected with CIV, CDV, and CnPnV – these co-infected dogs usually have very severe and life-threatening pneumonia.

The ability of *Mycoplasma cynos* to initiate primary respiratory infection is unclear as it is part of the normal flora in the upper respiratory tract. This bacterium is frequently identified in dogs with respiratory infections initiated by other pathogens. Lung tissue damage from viral infections promotes colonization by *Mycoplasma cynos* which contributes to disease severity and duration.

All of the respiratory pathogens are highly contagious in a high density/high turnover kennel setting. Factors that promote transmission include the immune status of the dogs, length of incubation period, preclinical shedding, subclinical shedding, duration of shedding, and aerosol and fomite transmission. These same factors also affect diagnosis and management and prevention strategies.

Pathogen Incubation and Shedding Periods

Except for CDV, the incubation period for all of the known bacterial and viral respiratory pathogens is 7 days or less. The short incubation period contributes to a rapid increase in number of dogs with kennel cough within a short period of time. In contrast, ***the incubation period for CDV is typically about 2 weeks in a population setting with many susceptible dogs without protective immunity***. This longer incubation period causes delays in recognizing affected dogs and contributes to a slow insidious increase in number of dogs with kennel cough and progressive disease.

Preclinical shedding occurs for all of the respiratory pathogens, meaning infected dogs are contagious before appearance of clinical signs. Virus shedding during the longer incubation period for CDV results in exposure of many more dogs before a problem is recognized and the adoption of apparently healthy dogs that subsequently become ill after transfer to adoption groups and new owners.

Most of the viral pathogens are shed in respiratory secretions for <14 days. After shedding ceases, the dog is no longer contagious to other dogs even though clinical signs may persist. The short shedding period contributes to feasibility of isolating affected dogs for 2 weeks before safely releasing back into the shelter population or to adoption groups or new owners. The ***important exceptions to a short contagious period are CDV, H3N2 CIV, Bordetella, Mycoplasma, and Strep zoo***. CDV is usually shed for weeks to months, even after clinical recovery. New evidence suggests that H3N2 CIV is shed

for 3 weeks. Chronic intermittent shedding of *Bordetella, Mycoplasma,* and *Strep zoo* for weeks can occur if they are not eliminated by appropriate antibiotic therapy.

	CAV2	CPiV	CDV	H3N8 CIV	H3N2 CIV	CRCoV	CnPnV	CHV
Incubation period	≤1 wk	≤1 wk	2 wks	≤1 wk	≤1 wk	≤1 wk	≤1 wk	≤1 wk
Shedding period	<2 wk	<2 wk	wks-mos	<2 wk	3 wks	<2 wk	<2 wk	<2 wk

	Bordetella	Mycoplasma	Strep zoo
Incubation period	≤1 wk	≤1 wk	≤1 wk
Shedding period (w/o antibiotics)	≤3 mo	weeks	weeks

Pathogen Transmission

All of the viral and bacterial respiratory pathogens are spread by contact with oronasal secretions from shedding dogs, contact with fomites (environmental and shelter staff), and contact with large droplets and aerosols from the respiratory tract generated by coughing and sneezing. Large droplets of respiratory secretions are sprayed in a 5-foot diameter zone around the infected dog. Aerosols, which are mists of very small respiratory droplets, can travel 20 feet or more and are a major source of respiratory pathogen spread in a kennel. This is the primary reason why ***clinically ill dogs should be promptly isolated from the population in order to decrease spread of infectious doses in the environment***. Remaining dogs in the same room must be considered exposed and potentially infected. ***Since CDV is multi-organ infection, virus is not only present in oronasal and ocular secretions, but also vomit, feces, and urine.***

Most of the viral and bacterial respiratory pathogens cause subclinical infections in a proportion of exposed dogs. Subclinically infected dogs shed the pathogen in oronasal secretions, but the amount of shed pathogen is typically much smaller and for shorter periods of time. However, the inability to identify subclinically infected dogs ensures that more dogs are exposed by direct contact.

Diagnosis

Since all the respiratory bacterial and viral pathogens cause kennel cough, at least during the first week of illness, ***the pathogen causing the infection cannot be diagnosed based on clinical signs!*** Most shelters assume that kennel cough is due to *Bordetella* bacterial infection and treat for several days with doxycycline antibiotic. Accumulating evidence from diagnostic testing indicates that ***most respiratory infections in shelter dogs are viral and typically involve more than one virus.*** Dogs infected with CPiV, CAV2, H3N8/H3N2 CIVs, CRCoV, CHV, and CnPnV may appear to respond to antibiotic treatment, but in reality, these viruses have “run their course” in a time frame that coincides with duration of antibiotic therapy. The exception once again is CDV – antibiotic treatment with doxycycline and other

antibiotics does not typically alter the disease severity or duration or progression to pneumonia and other complications.

Shelters should invest in diagnostic testing when:

1. The numbers of affected dogs increase above a typical baseline for the shelter
2. There is explosive spread throughout the population over a period of 2 weeks or so
3. Dogs progress to more severe disease or die
4. The duration of illness is more prolonged
5. There is an increased frequency of complaints from adopters, rescue groups, and community veterinarians about sick dogs coming from the shelter.

Timely diagnosis substantially impacts how many dogs remain healthy and adoptable. No diagnosis or late diagnosis increases the number of sick and exposed dogs and the number of dogs euthanized.

Diagnostic testing to identify the respiratory pathogen(s) provides for:

1. Proper patient management, including treatment options and costs, prognosis for recovery, and average time to recovery;
2. Proper management of the at-risk population
3. Isolation time for sick infected dogs (shedding period)
4. Quarantine time for asymptomatic exposed dogs (incubation period)

The best diagnostic test for acute respiratory infections is PCR for pathogen nucleic acid on nasal and pharyngeal swabs. PCR is very sensitive and specific. The turnaround time for results is usually 3 business days which allows for timely patient and population management. Several diagnostic laboratories offer CIRD PCR panels that test for multiple viral and bacterial respiratory pathogens in a single sample. Test costs range from $90 to >$120 per sample. IDEXX offers a substantial discount on their CIRD PCR panel for shelters. IDEXX also offers the most comprehensive CIRD PCR Panel that includes identification of CnPnV, any influenza A virus and *Strep zoo.* In addition, the IDEXX panel contains a quantitative CDV PCR assay that determines viral load in the sample. Viral load is useful in determining the probability that CDV is causing the active clinical disease, prognosis for severe disease, and time to recovery..

Timing of swab collection is critical for diagnostic accuracy – most viruses are shed for <14 days and peak shedding occurs during the incubation period and first 2-5 days after onset of clinical signs. To increase diagnostic accuracy and identify a pattern, swabs should be collected from at least 5 dogs with clinical signs for <5 days and from 5 asymptomatic dogs in close contact with sick dogs. The more dogs that are tested, the more confident you can be in the test results, especially if there is a consistent pattern of results for all tested dogs.

Sites to swab include the nasal cavity and caudal pharyngeal wall beyond the tongue. These sites should be rubbed with the swab tip to collect infected epithelial cells. At least 2 swabs should be collected from each dog and pooled together to maximize the probability of pathogen detection.

Although the multi-pathogen PCR panels are very sensitive and specific, PCR cannot reliably differentiate between modified-live vaccine strains and pathogenic wild type strains for *Bordetella*, CPiV, CAV2, and CDV. Studies have shown that the modified-live *Bordetella*, CAV2, and CPiV strains in the intranasal kennel cough vaccine can persist in the nasal cavity for up to 4 weeks postvaccination, causing difficulty in interpretation of positive PCR test results. Studies have also determined that the modified-live CDV vaccine strains given parenterally may be detected by PCR in <20% of dogs vaccinated within 2 weeks of testing, yielding potentially false positive results. The infection status may be clarified by the dog's clinical picture, known exposure to dogs with laboratory confirmed infections, the CDV viral load (IDEXX PCR test only), and patterns identified through testing of multiple dogs as denoted above.

Necropsy of dogs that die or are euthanized during respiratory disease problems is a valuable diagnostic tool. Tissues submitted for histopathology as well as diagnostic testing can help identify the pathogens and determine pathogenesis. Tissues should be fixed in large amounts of buffered formalin (9:1 ratio of formalin to tissue) for histology. Fresh unfixed tissues can be submitted for the IDEXX CIRD PCR panel and for bacterial culture. Necropsy is especially valuable since the pathogen may not be recognized or included in PCR panels.

Disease Management

Prompt isolation of clinically affected dogs is the single most effective strategy for controlling spread of respiratory infections. This reduces the infectious dose in the environment and threat of infection spillover to more susceptible dogs. These animals should be housed in a physically enclosed isolation room pending diagnostic testing. Diagnosis will direct treatment and isolation time. Most dogs recover from bacterial and viral pathogens that cause CIRD, including CDV. If shelters have enough space and staff, sick dogs can be held in isolation for 2 weeks for recovery and cessation of pathogen shedding. Dogs with H3N2 must be isolated for at least 3 weeks. Dogs with CDV must be isolated for weeks to months. Infected dogs in isolation should be cared for by staff wearing full PPE (hair cover, gown, gloves, boots) and using supplies dedicated to isolation. If the staff is responsible for care of other dogs, they should care for healthy dogs before working in the isolation area.

Since sick animals shed infectious respiratory pathogens before onset of clinical disease, all dogs exposed to sick animals either by direct contact or fomite contact should be consolidated into one housing area and quarantined for a time equal to the pathogen's typical incubation period. The incubation period for most respiratory pathogens is up to 1 week, so quarantine is a feasible option for most shelters. The infection status of exposed dogs is unknown and no dogs should leave quarantine until expiration of the quarantine time or diagnostic testing determines they are free from infection. If clinical signs occur, the dog should be immediately removed to the isolation area and the quarantine clock restarted for the remaining dogs. Another option to waiting out the quarantine clock is to determine the infection status of asymptomatic exposed dogs by conducting PCR testing on swabs. Staff caring for the quarantined population should wear full PPE and use supplies dedicated to quarantine. If the staff is responsible for care of other dogs, they should care for healthy unexposed dogs first, followed by quarantine, then isolation.

Compared to the other respiratory pathogens, management of CDV within a shelter is difficult due to the long incubation and shedding times. CDV is now considered a treatable disease from which most dogs recover, but the prolonged recovery time is not feasible for high density/high turnover shelters with limited housing space and inadequate isolation. This contributes to the decision by many shelters to euthanize infected dogs unless they can locate off-site housing or partner with another group to provide housing for recovery.

Sanitation

The canine viral and bacterial respiratory pathogens are easily inactivated by quaternary ammonium products, household bleach ((½ cup per gallon water), Wysiwash, Trifectant, and Accel/Rescue. Environmental surfaces contaminated with feces, urine, vomit, blood, and nasal discharge must first be cleaned with a detergent before applying the disinfectant product. The minimum contact time for the working dilutions of these disinfectants is 10 minutes. Air drying is preferred if possible, but if the animal needs to be returned to the same run or cage, the area should be rinsed and dried using a squeegee or towel. Moisture favors the survival of respiratory pathogens.

Daily cleaning and disinfection should include food and water bowls, animal transport vehicles, and hallways to reduce the risk for environmental transmission of any infectious disease. Mop buckets should not be used for cleaning and disinfection of kennel runs. High pressure hoses and power washers should also not be used in kennels unless all dogs are removed, because the force sprays feces on all surfaces and can even aerosolize fecal matter. Cleaning and disinfection supplies should be dedicated to each room and not removed for use in other areas in order to minimize cross contamination.

Prevention

Vaccines for CIRD pathogens do not induce immunity that prevents infection - the immunity reduces severity and duration of clinical disease as well as pathogen shedding. However, these vaccines generate population immunity that reduces pathogen transmission and prevention of outbreaks involving multiple dogs and forcing shelter closure. The one exception is the CDV vaccine - when dogs are properly vaccinated, this vaccine induces lifelong immunity that prevents infection.

Vaccination of all dogs on intake is the cornerstone for prevention of transmission of several respiratory pathogens (Bordetella, CPiV, CAV-2, CDV) in shelters. All dogs 4 weeks of age and older should receive an intranasal vaccine containing modified-live *Bordetella* and CPiV. This vaccine induces a rapid mucosal immune response against these within 3-7 days that reduces clinical disease and pathogen shedding. When administration of the intranasal vaccine is not feasible, the oral *Bordetella* vaccine should be given. Studies have shown the oral vaccine to be almost as effective as the intranasal vaccine and both are superior to the injectable killed *Bordetella* vaccine.

To generate immunity to CDV, CAV2, and CPiV, all dogs 4 weeks of age and older should receive the modified-live DAPP parenteral vaccine on intake, regardless of intake status (stray, owner surrender, rabies quarantine, cruelty case, pregnant, lactating, injured, mild illness). All dogs should be re-vaccinated with the DAPP combination 2 weeks after the intake vaccination. Puppies should be re-vaccinated with the DAPP vaccine every 2 weeks while in the shelter until they are at least 4 months old.

Restricting vaccinations to adoptable dogs only creates a large pool of susceptible animals that can make respiratory infections an endemic problem.

The H3N8/H3N2 CIV vaccine containing inactivated virus may not be feasible for use in high turnover shelters because it requires two doses and takes about 5 weeks to mount an effective immune response. However, once all dogs in the shelter have received at least the first dose and every new dog is vaccinated at intake, population immunity builds up to a level that can reduce flu virus transmission between dogs.

Many respiratory pathogens do not have a vaccine, including CRCoV, CnPnV, CHV, *Strep zoo*, and *Mycoplasma*.

Another strategy to reduce risk for respiratory infection is to move puppies from the shelter into foster care or adoption/rescue groups as soon as possible after intake. All efforts to reduce stress should be pursued. The most effective way is to prevent crowding by practicing sound population management strategies that decrease each animal's length of stay in the shelter.

Cynda Crawford, DVM, PhD
Maddie's Shelter Medicine Program
College of Veterinary Medicine
University of Florida
crawfordc@ufl.edu
(352) 258-9263