INFECTIOUS PNEUMONIA IN DOGS

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Community-acquired respiratory disease caused by infectious agents occurs commonly in dogs. Clinicians should develop a good understanding of the organisms isolated most frequently within their own local geographic area, and also those that are new or spreading into the area, for example Canine Influenza Virus. Once the organisms are understood, the clinician can make rational decisions about treatment for individual animals, and also make effective recommendations for management of epidemiology within populations.

Factors involved in infectious respiratory disease

There are three main factors involved in the development of infectious respiratory disease: invading pathogens, host factors, and environmental management. Typically, the most severely affected patients are impacted by all three factors.

Infectious pathogens:

The most common agents that cause infectious respiratory tract disease are viral and bacterial organisms. The most common viruses are parainfluenza virus, canine influenza virus, canine adenovirus type 2, and canine distemper virus. Newly emerging viruses that have not yet been well documented also include a respiratory form of canine coronavirus. The most commonly isolated bacteria that act as primary pathogens of the respiratory tract are *Bordetella bronchiseptica*, *Streptococcus zooepidemicus*, and *Mycoplasma spp*. In addition, secondary invasion by other bacteria is frequent, and the most commonly isolated secondary pathogens are gram negative enteric aerobes such as *E. coli*, and gram positive cocci such as Staphs and Streps.

Most dogs and puppies with contagious respiratory tract disease are actually infected with multiple organisms. When multiple pathogens are involved, and when the dose of pathogens to which the animal is exposed is high, the animal is likely to have more severe clinical symptoms of disease.

Host factors:

The severity of disease in an individual dog or puppy following exposure to respiratory infectious organisms depends on a variety of host-specific factors. In particular, the immune status of the animal may be affected by a variety of factors, including the age of the patient (puppies are susceptible to more severe disease), concurrent disease including parasitism, nutritional status, and other physiologic stresses such as weaning or change of ownership.

Further factors that are important include the specific immune status of the patient in regard to individual pathogens. For example, the morbidity rate in populations exposed to canine influenza virus is extremely high (often > 80%) because this is a relatively new virus and most
dogs do not yet have any immunity to it. In contrast, a dog that has recently received an intra-nasal vaccine against Bordetella may have significant mucosal immunity that is likely to decrease the severity of clinical signs if the dog is then exposed to this organism.

**Management factors:**

Management plays a significant role in the risk of development of community-acquired respiratory infections. Dogs placed in an environment that mixes animals from multiple sources, particularly if it is indoors in a shared airspace, are particularly at risk. Most of these organisms are spread by aerosolization, while transmission also occurs via fomites such as cages, food bowls, or handlers’ hands and clothes. Thus, dogs are at greatest risk of infectious respiratory disease if they are admitted to boarding kennels, shelters, groomers, doggie daycares, veterinary clinics and pet stores. The rate of transmission within these venues depends on the organism, the level of cleanliness, management factors such as the way quarantine is handled, and the degree of overcrowding.

**Diagnostic testing**

Pets with infectious respiratory disease almost always have a compatible history of exposure to other dogs, usually 2 days to 2 weeks prior to presentation for respiratory signs. For an individual pet dog, it is most important to clinically assess whether the dog is suffering from a viral or bacterial infection. Bacterial infections may need to be treated with specific antibiotics, while most viral infections simply require supportive care. For populations of dogs or puppies, it may be important to determine not just whether viruses are involved, but also which viruses are endemic in that population, in order to devise the most effective cleaning, quarantine and vaccination protocols.

Diagnostics for bacterial infection involve obtaining cultures (usually aerobic) from various sites in the respiratory tract. With the exception of *Strep zooepidemicus*, there are very few indications for obtaining bacterial cultures from the nose of the dog. In contrast, if the patient has alveolar disease, it is important to obtain cultures from deep down in the lung (by-passing the pharynx) using transtracheal or endotracheal washes. These cultures can allow the clinician to determine whether the problem is Bordetella or a secondary pathogen.

For viruses, the most common tools are virus isolation from nasal or pharyngeal swabs, PCR to identify virus in the same swabs, or serology to measure titers. Serology can be difficult to interpret if the dog has been vaccinated, eg canine distemper virus. When submitting tests for viruses, it is important to be mindful of the natural history of viral shedding depending on the virus involved. For example, canine influenza virus is shed in respiratory secretions for the first 7-10 days after exposure, and it is at this time that the dog is contagious to others. The virus can therefore be identified in respiratory secretions during the first week or so after exposure, but will not be identified if samples are obtained 2 weeks after the beginning of infection. At that time, serology is a better test. Additional tests may also be applicable to individual viruses, such as conjunctival scrapings to identify inclusion bodies of canine distemper, or immunofluorescence antibody tests for specific viruses on histopathology samples.
Assessing the individual dog

When presented with a patient with respiratory disease that is probably infectious, the first priority is to determine the severity of the respiratory tract involvement. In most cases, the infection is confined to the upper respiratory tract (nose, pharynx, trachea and mainstem bronchi). Clinical signs in these patients include coughing which can be severe, often accompanied by nasal discharge and sneezing. The key to identifying these less severely affected patients is that they are otherwise feeling well: they are active, happy, eating, and afebrile. Animals with primarily upper respiratory tract involvement do not usually require extensive diagnostic testing and should be managed as out-patients.

In a small proportion of cases (usually less than 10%, depending on the population and organisms involved), the infection extends to the lower respiratory tract (lower airways and alveoli). If there is inflammation of the alveoli, thoracic radiographs show evidence of alveolar infiltrates, and the term pneumonia is appropriately used. Dogs that are systemically ill, consistently febrile, anorexic, or showing signs of tachypnea or dyspnea in addition to their coughing should be selected for further diagnostics including thoracic radiographs, complete blood count, and potentially bacterial cultures. This more severely-affected subset may require in-patient management for fluid and oxygen therapy in addition to intravenous antibiotics.

Managing contagious respiratory disease in your practice

For the veterinary clinic, standard precautions include scheduling appointments for coughing dogs with a compatible history of exposure at the end of the day, holding the dog in the car until the time of the appointment (i.e. avoiding bringing the dog into the waiting room of the clinic), and bringing the patient into the building through a separate entrance in order to avoid any contact with other dogs. In addition, the examination should be performed in a “dedicated” room that will not be used for other patients until after it has been cleaned. For some infections especially canine influenza, staff should wear gowns, booties and disposable gloves to cover their clothing and should wash their hands and clean stethoscopes with alcohol before handling other patients. Staff members should also take care to change their clothes before contact with their own personal pets. If the dog is sick enough to require hospitalization, it should be held in a separate airspace from other hospitalized patients. Additional precautions might include restriction of staff members handling canine influenza patients to work only with patients of other species e.g. cats, for the rest of the day.

Most of the respiratory viruses including canine influenza are fragile and easy to kill with routine cleaning and disinfectants. Standard products containing quaternary ammonium compounds or bleach should be more than sufficient to eliminate these viruses from the environment, assuming that there is adequate contact time and that organic material has been removed prior to disinfection. Even without disinfectants, most of these viruses are believed to survive less than 48 hours in the environment.
Treatment

For treatment of primary or secondary bacterial infections, as a general rule, oral antibiotics can be used if the infection is confined to the upper respiratory tract (i.e., the dog is systemically healthy, eating well, and is not dyspneic). For adult dogs, doxycycline is inexpensive, effective, and readily available. For puppies if there is concern about tetracyclines affecting tooth enamel, then oral azithromycin is a well-tolerated and effective choice. Interestingly, the beta lactams such as amoxicillin, ampicillin, cephalosporins, and ticarcillin do not penetrate well into the mucus lining the bronchi (although they do penetrate well into alveoli), and therefore are less effective for treatment of Bordetella. Additional therapeutic options may include NSAIDS for treatment of fever, bronchodilators, mucolytics, or cough suppressants. Tamiflu® is not well studied and is not recommended for this application in dogs.

If there is evidence of pneumonia, then antibiotics should be administered by parenteral routes (ideally intravenously). Intravenous antibiotics are the best way of ensuring that adequate plasma concentrations are achieved, because there is no guarantee of adequate absorption of drugs from the gut in such sick animals. Dogs with severe pneumonia require aggressive antibiotic therapy especially if they are dyspneic. For puppies, consider starting with a combination of ampicillin and an aminoglycoside (once dehydration has been corrected) to provide adequate coverage for gram-negative aerobic secondary invaders, in addition to azithromycin which provides optimal coverage for Bordetella. When ampicillin is combined with an aminoglycoside, a synergistic effect provides excellent broad-spectrum coverage in serious respiratory infections. Other options such as fluoroquinolones or tetracyclines should ideally be avoided in puppies because of their respective adverse effects on joints and teeth. For adult dogs with infectious pneumonia, the fluoroquinolones can be used alone or in combination with ampicillin, providing an excellent spectrum of coverage for both gram-negative aerobes and also Bordetella, and have excellent penetration of the lungs. Once culture and sensitivity results are available, a specific and narrow-spectrum antibiotic can then be chosen for ongoing care.

Airway hygiene and clearance of secretions for pneumonia cases

Clearance of secretions from the airways occurs via the mucociliary escalator and cough reflex, and is delayed if the secretions are extremely viscous and tenacious. In dogs and cats with pneumonia, large amounts of viscous secretions are produced, and attempts to resolve the infection must include attention to the character of the respiratory secretions. Productive coughing must be actively encouraged, and the secretions must be maintained as liquid as possible. More than 90% of the mucus in the respiratory tract is water, so even a mild degree of dehydration leads to drying of the secretions. The most important means by which this is achieved is by parenteral fluid therapy. Unless extreme respiratory distress is present, these patients should not be allowed to become dehydrated, and diuretic use should be avoided.

The tenacity of mucus also depends on the structure of the mucopolysaccharides that it contains. N-acetylcysteine can be administered intravenously or orally, and acts as a mucolytic by opening disulfide bonds, thereby decreasing the viscosity of the mucus. It can also be administered by nebulization, but it can cause bronchospasm by this route, which is usually manifested by coughing. If coughing or dyspnea occurs, the patient may be pre-treated with bronchodilators prior
to nebulization. Phenolic compounds such as guaiphenesin (Mucinex®), and inhaled volatile oils such as eucalyptus oil, may directly stimulate production of increased amounts of watery mucus.

Nebulization is a technique in which tiny spherical droplets of saline are generated and inhaled by the patient. The droplets then "shower out" at various levels of the respiratory tract, depending on their size, due to changes in direction of air flow, brownian motion, and gravity. Droplets greater than 10 microns reach only the upper airway and trachea. In the range of 1-10 microns, the smaller the droplet, the deeper it is able to penetrate into the respiratory tract. Droplets less than 0.5 microns reach the alveoli and are exhaled. Most ultrasonic nebulizers create droplets in the 2-5 micron range. Typically 0.9% or 0.45% saline is used for nebulization rather than sterile water. Because nebulization adds significant amounts of liquid to the respiratory mucosa, use of water would be create an excessively hypotonic environment for the mucosal epithelial cells.

Once the respiratory tract secretions have been moistened and increased in volume, clearance of the material depends on normal function of the other respiratory defense mechanisms. Atelectasis predisposes to pneumonia because bacteria can be trapped and proliferate in collapsed airspaces and cannot effectively be cleared by the mucociliary escalator. Recumbent animals may have prolonged or recurrent atelectasis, and because they are weak and sometimes painful they may also have a depressed cough reflex, further impairing their ability to clear organisms and material from their airways. Therefore, dogs with pneumonia should not be allowed to lie in one place for long periods of time.

In particular, the cough reflex is a vital part of recovery from serious pneumonia. The simplest method of stimulating coughing is simply to stimulate an increased tidal volume during respiration, usually by mild exercise. The amount of exercise needed to increase the tidal volume and respiration rate is variable depending on the severity of disease. In some, simply turning the animal from one side to the other in lateral recumbency is enough. The next step may be to stand the patient for brief periods of time, then to take a few steps, gradually building strength and mobility. Mild to moderate exercise often stimulates productive coughing which should be encouraged by coupage.

Coupage is the action of firmly striking the chest wall of the patient with a cupped hand, which helps to stimulate the cough reflex and to "break up" secretions in the airways. Coupage should be performed several times daily, especially in patients that are unable to stand and move around. It is usually well tolerated, except in patients that have experienced thoracic trauma or thoracic surgery.

Monitoring the pneumonia patient during therapy

Pneumonia patients must be monitored carefully to ensure that they are continuing to respond appropriately to therapy. Radiographs of the chest should be obtained periodically during hospitalization (about every 3-4 days) to confirm that the alveolar disease is resolving. Failure to achieve clinical or radiographic improvement should prompt reconsideration of antibiotic therapy, repeat tracheal wash culture, or repeated attempts to resolve the underlying cause of the pneumonia.
In dogs that are hypoxic, lung function should be repeatedly evaluated by monitoring arterial blood gases or pulse oximetry. The pulse oximeter can be used for intermittent monitoring of oxygen saturation, or alternatively it can be used to provide a continuous real-time read-out, which is particularly useful for monitoring general anesthesia or sedation. The pulse oximeter can also be used to monitor changes in saturation when stressful procedures are being performed, for example transtracheal washes or radiographs. This technique allows the clinician to determine whether a need exists for oxygen supplementation, and also to objectively assess the response in terms of an increase in oxygen saturation. Pulse oximetry readings of < 94% are clinically significant, and should be addressed immediately with oxygen supplementation. Desaturation in dogs that are already on oxygen supplementation is a serious situation. Arterial blood gas analysis is the gold standard for direct assessment of pulmonary function, and it also provides information about the metabolic acid-base status of the body. Normal partial pressure of oxygen is expected to be 90-100 mmHg when the animal is breathing room air, and results < 80 mmHg are clinically significant. Normal partial pressure of carbon dioxide is 35-45 mmHg, and clinically significant hypoventilation occurs when carbon dioxide is > 50 mmHg. Most dogs with bacterial pneumonia experience hyperventilation and slightly low carbon dioxide concentrations. Sequential analysis of arterial blood gas results is the most accurate tool for objectively assessing trends in response to treatment.

Once the lung function has returned to normal, and the patient is feeling better, eating well, and is active and alert, oral antibiotic therapy can be instituted and discharge from the hospital can be considered. In most patients, this occurs 3-14 days from hospital admission. The patient should be re-examined in about one week to obtain chest radiographs to confirm that the pneumonia is continuing to resolve. In severe cases, several weeks of therapy may be required for complete resolution of radiographic signs of pneumonia. As long as the animal is doing well clinically, it should be radiographed approximately every 2-3 weeks until the radiographs are normal. Oral antibiotic therapy should be continued for a further 2 weeks after radiographic resolution of the disease, in order to assure that the bacterial infection has been completely eliminated.

REFERENCES AVAILABLE ON REQUEST