Treatment of Bacterial Pneumonia

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Bacterial pneumonia encompasses a wide spectrum of disease from chronic to acute, unilobar or multilobar, and with clinical signs ranging from mild tachypnea or cough to rapidly progressive and fatal pulmonary infection. Cats are subject to bacterial pneumonia far less frequently than are dogs. It is important to understand that bacterial pneumonia is rare in otherwise healthy animals. Although there are a few primary bacterial respiratory pathogens (e.g., Bordetella bronchiseptica), most cases of bacterial pneumonia result from opportunistic infections. The animal is typically debilitated, immunosuppressed, or has a compromise to local protective mechanisms before contracting bacterial pneumonia. Reasonable efforts should be made to identify underlying predisposing factors (e.g., megaesophagus, immune deficiency states) at the onset of treatment. These underlying conditions make treatment of bacterial pneumonia all the more challenging. Severe bacterial pneumonia causes clinical signs related to infection and clinical signs related to hypoxemia resulting from ventilation-perfusion mismatching. Treatment must involve attempts to eradicate the causative bacterial agent and also supportive care.

Pathogens

Pathogens incriminated are often opportunistic, and include enteric pathogens (e.g., E. coli, Klebsiella), Pasteurella spp., coagulase-positive Staphylococci, Streptococci, and Mycoplasma spp.. Bordetella bronchiseptica is a very common cause of pneumonia in puppies. Transtracheal wash or blind bronchoalveolar lavage provides material for cytologic exam and culture prior to initiation of broad-spectrum antibiotics. Because antimicrobial treatment is often prolonged, it is important to actually identify the offending pathogen(s) and determine susceptibility. Overly broad, toxic, or expensive treatment can be avoided simply by performing a timely culture and sensitivity from the airways.

Therapy

Antimicrobials

All bacterial pneumonia should be treated with antimicrobial drugs. Ideally, therapy should be based on culture and sensitivity results. Transtracheal wash can be performed with minimal or no sedation, and endotracheal wash requires only a very brief anesthetic episode. Antimicrobial drugs should be instituted before culture results become available, and then adjusted later. When considering antimicrobial choices for the respiratory tract the "blood bronchus barrier" must be considered as it effects penetration of systemic antibiotics into the airway lumen. However, unlike when treating tracheobronchitis, treating pneumonia means treating the well-vascularized lung parenchyma. Further, the inflammation that accompanies bacterial pneumonia may allow the penetration of drugs that otherwise would not reach adequate airway concentrations (e.g., beta lactams antibiotics). Initial spectrum of activity depends on the disease severity; the more severe the disease, the more aggressive should be the therapy. The organisms most commonly implicated in bacterial pneumonia include enteric pathogens (~50%) and anaerobes (20-25%); polymicrobial infections are common. To achieve broad spectrum coverage it is common to use combination therapy. The author typically begins with a fluoroquinolone combined with a beta-lactam, but other drugs or combinations are equally useful (e.g., beta lactams plus aminoglycosides or second generation cephalosporin; or ticarcillin or meropenem alone). Parenteral administration is used as the initial delivery route for the most severely affected animals of for those that can't take oral medications. Typically if the animal's condition has improved after several days an oral route of administration is adopted. Once antimicrobial susceptibilities have been determined, the antibiotic with the narrowest effective spectrum of action should be used. For dogs less severely affected at initial diagnosis, other antibiotic therapies, like trimethoprim sulfa or amoxicillin-clavulanate, may be appropriate pending culture results. Duration of therapy is typically at least one week past an apparent radiographic cure, or a minimum of 3 weeks.

Oxygenation

Dogs with severe bacterial pneumonia are often hypoxemic. Ideally, PaO_2 is determined via arterial blood gas, or alternatively, SpO_2 is used as a rough correlate. Oxygen supplementation should be provided when PaO_2 is <80 mmHg or the SpO_2 is <94%. The most practical means of delivery is placement of a nasal cannula, or oxygen cages for cats or small dogs (cages use far more oxygen). Oxygen should be humidified prior to delivery to prevent drying of the airways with resultant impaired mucociliary clearance. The FIO_2 should be kept at a minimum effective level since oxygen is itself toxic in high concentration over time. Ideally, a maximum of 40% FiO_2 should be used. On occasion higher concentrations are required but should be used for less than 2 days if at all possible. For animals that remain markedly hypoxemic, fail to adequately eliminate CO_2, or are threatened with respiratory exhaustion, ventilator therapy may be the only option for continued care.

Hydration

Fluid therapy is an important part of the treatment of animals with severe bacterial pneumonia. These animals are weak, depressed and often febrile and therefore susceptible to dehydration. In addition to the systemic effects of dehydration, dehydration can cause the mucus layer of airway secretions to become dehydrated as well. The mucociliary escalator functions to trap particulates and bacteria,

move them craniad via directional movement of cilia, and allow particulates to reach the oropharynx where they can be expelled through coughing swallowing. The mucus itself is made of two layers – the watery sol layer through with the cilia move, and the overlying gel layer that traps the particulates. If the sol layer becomes dehydrated, the cilia themselves can become entrapped in the gel layer impeding the free movement of the cilia and thereby effectively inhibiting the mucociliary escalator. Both systemic fluid therapy and airway nebulization can contribute to the more effective action of the mucociliary escalator by allowing the sol layer to perform as required.

Miscellaneous

Importantly, cough suppressants should NOT be used to treat animals with bacterial pneumonia. Instead, the goal should be to encourage cough and subsequent removal of infected sputum. This is the reasoning behind the use of physical therapy techniques such as coupage. Using a cupped hand clapping motion on either side of the chest several times a day, combined with frequent turning of recumbent patients and encouraging short walks may help induce cough and encourage clearance of sputum. Nebulization of the airways will help make the mucus layer thinner and more able to be moved by the mucociliary escalator. There is no proof that the addition of antibiotics to nebulized fluid improves the clinical outcome, and nebulized antibiotics must never be substituted for systemic antibiotics, even if they are used as an adjunctive therapy. Nebulizers should secrete particles between 0.5 and 3.0 micrometers, a feat that is not accomplished with simple room humidifiers. Saline nebulization is effective alone, although sometimes other agents such as mucolytics (N-acetylcysteine) or antibiotics (often aminoglycosides) are added to the nebulization solution. When products are added to the nebulization solutions that were not made for that purpose (e.g., non-respiratory formulations of gentamicin or amikacin) it must be recognized that a percentage of animals may develop bronchoconstriction in response to additives or preservatives in the product. Bronchoconstriction commonly follows nebulization of N-acetylcysteine too, so the author does not use this product by the inhalant route. Oral N-acetylcysteine is not proven to be helpful, but it is safe and inexpensive, and the author admits to using it on occasion in animals with pneumonia. The routine use of bronchodilators in the treatment of bacterial pneumonia remains controversial. The author does not use bronchodilators on a routine basis, but may consider the use of either albuterol inhalers or oral methylxanthine type drugs (e.g., theophylline) in animals that remain hypoxemic despite oxygen supplementation.

In cases of severe bacterial pneumonia that fail to clear in response to standard therapy, especially those in which one lung lobe is involved, consideration should be given to lobectomy. Often, such infections are due to an underlying physical problem in that single lobe such as bronchial foreign body or tumor. Removal of the lobe may result in cure in such cases. The removed lung should be submitted both for tissue culture and for histopathology.

Unusual types of bacterial pneumonia

There are specific bacterial causes of infectious pneumonia worth mention. Both Ehrlichia and *Rickettsia rickettsii* may have pulmonary manifestation due to vasculitis. Mycoplasma, fastidious microbes that lack a cell wall, may play a primary or secondary role in pulmonary infection of dogs and cats. They are resistant to many commonly used antibiotics, but are generally susceptible to macrolides, tetracyclines, chloramphenicol, and fluoroquinolones. Dogs and cats are rarely diagnosed with acid-fast mycobacterial infections. Basset hounds and Siamese cats have been most often reported to have *M. avium* infections. *M bovis* (tuberculosis) is a reverse zoonoses, which dogs acquire from and infected human. Because of the typical hilar lymphadenomegaly and nodular or interstitial nodular lung patterns, mycobacterial infections may mimic pulmonary neoplasia. Cats in the southwestern USA may develop pneumonia as a result of *Yersinia pestis* infection; although uncommon, this is extremely important as a potentially fatal zoonosis.

Summary

The author's typical management of a dog suffering from severe bacterial pneumonia would include intravenous crystalloid fluids at a rate to provide maintenance needs, correct dehydration, and account for ongoing losses. Parenteral broad spectrum antimicrobials would be initiated pending culture results, most often consisting of ampicillin (20 mg/kg IV TID) and enrofloxacin (5 mg/kg IV diluted 50:50 in saline and given slowly BID or IV ciprofloxacin). Saline nebulization and coupage would each be performed QID. Oxygen would be supplied, typically by nasal cannula, if PaO_2 is <80 mmHg or SpO_2 is <94%. If the animal remains anorectic for more than 3 days, nutritional support should be initiated.