

Compendium

Aspiration Pneumonia in Dogs: Treatment, Monitoring, and Prognosis

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Abstract: Aspiration pneumonia and aspiration pneumonitis are associated with significant morbidity in both veterinary and human medicine. A variety of medical conditions and medications can predispose patients to aspiration. Ideally, aspiration should be prevented, but in dogs that develop aspiration pneumonia, close monitoring and supportive care are imperative. This article describes antimicrobial treatment, fluid therapy, ancillary medical therapy, oxygen therapy, and prognosis for aspiration pneumonia.

For more information, please see the companion article, "Aspiration Pneumonia in Dogs: Pathophysiology, Prevention, and Diagnosis."

Treatment

Antimicrobials are the gold standard for treatment of aspiration pneumonia; however, additional supportive care is often indicated.

Antibiotic Therapy

Aspiration pneumonitis is a sterile process; therefore, antimicrobials are not routinely indicated for this condition. There is also the concern that indiscriminate antimicrobial use may select for resistant strains of bacteria. Despite these concerns and the known pathophysiology of aspiration pneumonia, human and veterinary patients are often treated with empiric antimicrobials during the pneumonitis phase without confirmation of an infectious process.¹⁻³ Supportive care and monitoring are indicated after a witnessed aspiration event. If signs are progressive, severe, or have not resolved within 48 hours, antimicrobial therapy should be initiated.^{4,5} Exceptions include patients that aspirate gastric contents that may have been colonized by enteric bacteria due to acid-reducing medications or gastrointestinal obstruction.^{4,5}

The duration of illness is often difficult to ascertain in patients presenting with signs suggestive of pneumonia. Patients presenting with fever, dyspnea, a moderate to severe cough, and/or a history of a predisposing etiology often are treated empirically for infection.¹⁻³

The antimicrobial sensitivities of bacterial agents responsible for pneumonia may vary depending on whether the animal was hospitalized when the aspiration event occurred. Patients currently or recently receiving antimicrobial therapy may be infected by

bacteria that are resistant to previously administered antimicrobials. Patients with nosocomial infections may have a particular sensitivity pattern characteristic of the hospital. In these cases, empiric antimicrobial therapy should be guided by known hospital sensitivity patterns. When the hospital sensitivities are not known or aspiration occurs outside the hospital environment, broad-spectrum coverage is indicated.^{4,6}

Collection of pulmonary fluid samples for cytology, culture, and sensitivity should be performed before initiation of antimicrobial therapy in all patients stable enough for the procedure. Culture of samples obtained from human and veterinary patients already receiving antimicrobials has been shown to be useful.^{7,8} A study of puppies with community-acquired pneumonia found tracheal wash cultures positive for *Bordetella bronchiseptica* in patients that had received antimicrobial therapy.⁷ In a human study, there was no statistical difference in the frequency of positive sputum cultures between patients who had received prediagnostic antimicrobials and those who had not.⁸

Broad-spectrum antimicrobial therapy, including coverage for gram-negative and gram-positive bacteria, should be initiated while

Key Points

- Antimicrobials are the gold standard of therapy for patients with aspiration pneumonia, but additional medical and supportive care is often indicated.
- Oxygen therapy should be initiated in hypoxemic, hypercapnic, or dyspneic patients.
- Nebulization and cough along with mucolytic therapy helps clear airway secretions.

microbiologic test results are pending. In-house cytology and Gram stain of an airway fluid sample is helpful to evaluate the types of cells present and obtain a preliminary evaluation of the bacteria present while culture results are pending. Intracellular bacteria are indicative of a true infection, whereas the presence of extracellular bacteria may represent contamination or recent aspiration. Fluid examined via cytology is usually inflammatory in nature with a preponderance of neutrophils; however, mixed inflammatory infiltrates can be seen.⁹ As many patients are inappetent, parenteral medications should be chosen for initial therapy. Good empiric parenteral choices for gram-negative coverage include fluoroquinolones, aminoglycosides, and ticarcillin-clavulanic acid.¹⁰ Fluoroquinolones have excellent penetration of the blood-bronchus barrier, whereas aminoglycosides only reach 30% to 40% of serum levels in endobronchial secretions.⁶ Gram-positive coverage is provided with ampicillin, a first-generation cephalosporin, or ticarcillin-clavulanic acid. Although cephalosporins and ampicillin penetrate the pulmonary parenchyma, they have poor penetration into bronchial secretions.⁶ However, the breakdown of the blood-bronchus barrier with pneumonia may allow these antimicrobials to penetrate the airway. A 2010 study of aspiration pneumonia in dogs showed no difference in survival based on antimicrobial choice.¹¹

In human medicine, controversy exists as to the role that anaerobic bacteria play in aspiration pneumonia. While some believe that specific coverage is unnecessary unless a pulmonary abscess is suspected,^{5,12} other investigators report the significant role anaerobes play in pneumonia.¹³ The role of anaerobes in canine aspiration pneumonia is unknown.⁶ Anaerobes can be difficult to culture, although one report indicated that 22% of cultures were positive for anaerobes in dogs.¹⁴ Until the role of these organisms in canine aspiration pneumonia is discerned, the use of broad-spectrum antimicrobial therapy with adequate coverage for anaerobes is prudent.

Fluid Therapy

Intravenous fluid therapy is indicated in most patients with pneumonia because many are inappetent, dehydrated, and potentially hypovolemic. Fluid loss through the respiratory tract is increased due to panting or tachypnea and increased mucus production. Providing adequate hydration to these patients is necessary to liquefy pulmonary secretions, enabling more rapid clearance of mucus from the airways. However, increased pulmonary vascular permeability in patients with pneumonia necessitates careful consideration of fluid administration because increasing pulmonary vascular hydrostatic pressure may contribute to interstitial edema and alveolar flooding.⁶

The use of synthetic colloids in patients with aspiration pneumonia has also been a topic of debate. In patients with hypoproteinemia and low colloid osmotic pressure, colloid therapy may be beneficial to help prevent leakage from the intravascular space. However, colloid particles may theoretically leak from the damaged pulmonary vasculature, pulling fluid into the interstitium and exacerbating pulmonary edema. Hydroxyethyl starch (HES) has been shown to reduce microvascular permeability, possibly by

Box 1. Properties of *N*-Acetylcysteine^{19,20}

- Donates glutathione
- Scavenges free radicals
- Decreases neutrophil migration
- Inhibits cytokine release
- Clears apoptotic cells in the presence of lipopolysaccharide-induced inflammation
- Disrupts disulfide bonds in mucoproteins, thereby reducing secretion viscosity

“plugging” the leaks in the endothelium.¹⁵ HES may also have antiinflammatory effects.^{15,16}

Nebulization and Coupage

Nebulization with 0.9% saline humidifies pulmonary secretions and enhances clearance.¹⁰ Nebulization with 7.0% hypertonic saline (HTS) has been used in people with cystic fibrosis. HTS rehydrates alveolar mucus osmotically and enhances mucociliary clearance of particulates and bacteria.¹⁷ HTS nebulization is being considered for other pulmonary diseases, including bacterial pneumonia.¹⁷ Nebulization with antimicrobials, specifically aminoglycosides, has been used in both human¹⁷ and veterinary¹⁸ medicine because the antimicrobial can reach therapeutic concentrations in the lower respiratory tract. Coupage, encouraging ambulation, and rotating recumbent patients every 4 hours helps mobilize airway secretions and facilitate expectoration.

Mucolytics/Antioxidants

N-acetylcysteine is a commonly used mucolytic in the treatment of pulmonary disease with excessive or thick mucus production. The free sulfhydryl group on the drug is believed to reduce and disrupt disulfide linkages in mucoproteins, thereby reducing the viscosity of secretions and enhancing their removal.¹⁸ The compound is available as a sterile intravenous solution, a solution for inhalation, and an oral form. *N*-acetylcysteine itself is very irritating to the respiratory tract when delivered as an aerosol. However, a lysine salt derivative that is less irritating is being produced in Europe (Nacystelyn, SMB Pharmaceuticals, Brussels, Belgium).¹⁹ It is currently not available in the United States.

N-acetylcysteine also has antioxidant and immunomodulatory effects (BOX 1).^{19,20} These properties, in theory, provide the reason for use of this medication as an adjunctive treatment for inflammatory lung diseases, including pneumonia.

Bronchodilators

Bronchodilator use in pneumonia is controversial. Phosphodiesterase inhibitors (aminophylline, theophylline) and β_2 agonists (terbutaline, albuterol) help relieve the bronchoconstriction that is seen immediately after aspiration of acidic gastric contents. β_2 agonists stimulate secretion of airway mucus, which lowers the viscosity of airway fluid and enhances mucociliary clearance,

Box 2. Indications for Supplemental Oxygen²⁶

- $P_{aO_2} < 70$ mm Hg ($SpO_2 < 93\%$). In dogs (based on the oxyhemoglobin dissociation curve):
 - A P_{aO_2} of 80 mm Hg corresponds to an SpO_2 of 95%.
 - A P_{aO_2} of 60 mm Hg corresponds to an SpO_2 of 90%.
- Severe anemia
- Cardiovascular instability
- Signs of respiratory distress: dyspnea, orthopnea, tachypnea, restlessness

whereas phosphodiesterase inhibitors have significant antiinflammatory effects.¹⁸ Both types of bronchodilators, however, can suppress the cough reflex and impede expectoration or allow exudates to spread to previously unaffected areas of the lung, allowing progression of disease.²¹ Bronchodilators may also worsen oxygenation and ventilation by opening diseased airways and increasing dead-space ventilation. Possible side effects of bronchodilators include tachycardia and central nervous system stimulation. Bronchodilators can be considered for patients with bronchoconstriction. Their use should be reserved for patients without underlying significant cardiac disease.

Corticosteroids

The pulmonary inflammation triggered by aspiration itself contributes significantly to the progression of aspiration pneumonia. Corticosteroids have received some attention due to their potential to modulate this inflammation in patients with severe pneumonia.²² However, corticosteroid use can be associated with significant gastrointestinal signs such as vomiting, diarrhea, melena, and hematemesis.^{23,24} The potential for immunosuppression and worsening of infection is also a factor to consider when contemplating the use of corticosteroids.²⁵ The potential risks of corticosteroid use outweigh the benefits of routine use until more studies to evaluate their use in aspiration pneumonia have been performed.²² However, low-dose steroid administration in patients with aspiration pneumonia and relative adrenal insufficiency (also called critical illness-related corticosteroid insufficiency [CIRCI]) may be indicated if septic shock is present.

Oxygen Therapy

Oxygen therapy is indicated when pulse oximetry or arterial blood gas analysis provides objective evidence of hypoxemia or hypoventilation or if dyspnea is present (**BOX 2**). Oxygen cages, nasal catheters, oxygen hoods, nasal cannulae/prongs, and flow-by techniques are all methods of supplementing inspired oxygen at variable concentrations.²⁶ Oxygen cages provide a nonstressful environment for the patient but limit patient handling or auditory assessment of breathing (i.e., stertor or stridor). Nasal catheter placement is noninvasive, technically simple to perform, and requires no specialized equipment. Flow rates of up to 100 mL/kg/min per catheter are tolerated well by patients, and with placement of bilateral catheters, inspired oxygen concentrations of 60% can be

Box 3. Indications for Mechanical Ventilation²⁸

- $P_{aO_2} < 60$ mm Hg despite supplemental oxygen
- $P_{aCO_2} > 60$ mm Hg
- Impending respiratory fatigue/failure

achieved.²⁷ Supplementation of oxygen at concentrations of 60% or higher should be limited to 24 hours or less to avoid oxygen toxicosis. With prolonged high levels of oxygen supplementation, oxygen-derived free radicals damage the respiratory epithelium and cause inflammation leading to high-protein edema and possible secondary pulmonary fibrosis.²⁶

Mechanical ventilation should be considered for patients that remain hypoxemic or hypercapnic despite supplemental oxygen therapy (**BOX 3**).²⁸ In addition, patients that demonstrate clinical evidence of impending respiratory fatigue or arrest benefit from prompt institution of this therapy to minimize patient suffering and maximize the chance of a successful outcome.

Monitoring

Patients should be monitored closely while hospitalized for treatment of aspiration pneumonia. Vital sign trends (e.g., body temperature, respiratory rate and effort, blood pressure) help guide supportive care and identify patients with systemic inflammatory response syndrome. Monitoring arterial blood gas and pulse oximetry measurements guides oxygen therapy and its subsequent discontinuation (**BOX 2**). Periodic complete blood counts or peripheral blood smears, coagulation profiles, and chemistry panels evaluating renal and hepatic enzyme and protein levels may identify patients that are developing multiple organ dysfunction syndrome or experiencing adverse drug effects. Serial evaluation of thoracic radiographs helps to determine response to therapy but should be interpreted in light of clinical response because resolution of radiographic signs may lag behind clinical improvement.

Follow-Up

Patients can be transitioned to oral medications, including antimicrobials, when they are hemodynamically stable and have an adequate oxygenation status to ensure appropriate splanchnic perfusion and oxygen delivery to allow absorption of oral medications. Hypotension, hypoxemia, hypothermia, and/or lack of auscultable bowel sounds indicate that a patient is not stable enough to receive enteral medications, and parenteral medications should be continued. Patients may be discharged when they are maintaining adequate oxygenation and ventilating well on room air with no evidence of dyspnea or tachypnea, are eating and drinking adequately to maintain nutritional and hydration status, and can tolerate oral medication. Patients should be discharged with instructions for recheck radiography at least every 2 weeks until there is radiographic resolution of the pneumonia. Oral antimicrobials should be continued for at least 3 to 4 weeks and for 1 to 2 weeks past radiographic resolution to ensure complete clearance of pulmonary infection.⁶

Clinical Pearls

- Culture of airway fluid exudate can be performed after initiation of antimicrobials.
- Empirical antimicrobial coverage should be broad-spectrum or based on hospital sensitivity patterns.
- Cytologic examination of an airway fluid sample helps to guide initial antimicrobial therapy.
- Definitive antimicrobial choices should be based on airway fluid culture and antimicrobial sensitivity.
- Antimicrobials should be continued for a minimum of 3 to 4 weeks.

Prognosis

Overall, patients diagnosed with aspiration pneumonia have a fair to good prognosis for survival with supportive care. Survival rates of 77% to 82% have been reported, but these studies did not distinguish patients that died from patients that were euthanized.^{3,11} Survival has not been shown to be related to the character or number of predisposing etiologies.³ Recurrent aspiration from chronic diseases such as laryngeal paralysis, however, may contribute to an owner's decision to euthanize.^{29,30} Studies have found that the severity of radiographic

signs (interstitial or alveolar) does not correlate with survival,³ but the number of lung lobes involved may or may not be a prognostic indicator.^{3,11} Further studies are needed to investigate possible prognostic information that may be determined from thoracic radiographs.

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1. A 4-year-old male, intact Labrador retriever presents with a 2-day history of vomiting. During the examination, the patient regurgitates, and aspiration is suspected. Other than a tense abdomen, the physical examination is within normal limits. The patient is not currently receiving any medications. When should antimicrobial therapy be initiated?
 - a. immediately, to try to prevent pneumonia from developing
 - b. within 24 hours after the witnessed event
 - c. only after samples of airway exudate have been obtained for analysis
 - d. if clinical signs develop that are suggestive of pneumonia
2. The patient in question #1 has been hospitalized for diagnostics and supportive care. Within the first 6 hours, he begins to cough and becomes febrile and tachypneic. Thoracic radiography shows pulmonary infiltrates in the right cranial lung lobe. If the patient has normal chemistry panel and urinalysis results, empiric broad-spectrum antibiotic coverage may be provided with which combination of antimicrobials?
 - a. enrofloxacin and doxycycline
 - b. doxycycline and metronidazole
 - c. enrofloxacin and metronidazole
 - d. ampicillin and enrofloxacin
3. Which property of HES may prove beneficial in the treatment of aspiration pneumonia?
 - a. provision of coagulation factors
 - b. reduction of mucus secretion
 - c. provision of colloid support
 - d. promotion of inflammation
4. Which of the following statements is true with regard to *N*-acetylcysteine?
 - a. It is a source of glycine.
 - b. It induces the migration of neutrophils to the site of infection.
 - c. It is an antioxidant.
 - d. It increases the viscosity of airway secretions.
5. Potential concerns with the use of bronchodilators in patients with aspiration pneumonia include
 - a. bradycardia.
 - b. decreased viscosity of airway secretions.
 - c. stimulation of inflammatory cytokine release.
 - d. suppression of the cough reflex.
6. Pulse oximetry (SpO_2) is often used as a surrogate for arterial blood gas analysis as a way to monitor a patient's oxygenation status. However, this relationship is not linear. For example, an SpO_2 of 95% correlates with a PaO_2 of _____ mm Hg.
 - a. 60
 - b. 70
 - c. 80
 - d. 90
7. A benefit of oxygen delivery by nasal catheter is that
 - a. oxygen toxicosis cannot occur.
 - b. patients are necessarily isolated from the hospital environment.
 - c. bilateral placement allows supplementation of up to 40% oxygen.
 - d. placement is technically easy.
8. Which of the following medications cannot be recommended for treatment of aspiration pneumonia at this time?
 - a. bronchodilators
 - b. medium-/high-dose corticosteroids
 - c. antibiotics
 - d. *N*-acetylcysteine
9. Which of the following antibiotics can penetrate the blood-bronchial barrier in a patient with normal pulmonary vascular permeability?
 - a. amikacin
 - b. ampicillin
 - c. enrofloxacin
 - d. cefazolin
10. To limit the potential for oxygen toxicosis, the duration of supplemental oxygen therapy at a concentration $\geq 60\%$ should be limited to no more than _____ hours.
 - a. 6
 - b. 12
 - c. 24
 - d. 48