Aspiration Pneumonia in Dogs: Pathophysiology, Prevention, and Diagnosis

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Abstract: Aspiration pneumonia and aspiration pneumonitis are associated with significant morbidity in veterinary and human medicine. A variety of medical conditions and medications can predispose patients to aspiration, and every precaution should be taken to prevent aspiration from occurring. For dogs that aspirate oral or gastric contents and subsequently develop pneumonia, monitoring and supportive care are imperative. This article discusses the pathophysiology, prevention, and diagnosis of aspiration pneumonia.

Pathophysiology
Aspiration pneumonia develops in three stages. The first stage occurs immediately after aspiration. During this phase, damage to the airways and pulmonary parenchyma is a direct result of the nature of the aspirated fluid (i.e., irritant or acidic). This caustic tissue damage triggers the activation of cytokines and other inflammatory mediators. The inflammation leads to necrosis of type I alveolar cells, bronchiolar constriction, pulmonary hemorrhage, increased mucus production, increased vascular permeability resulting in extravasation of proteins into the pulmonary parenchyma, and pulmonary edema. Ultimately, alveolar collapse and atelectasis result. The second phase of aspiration pneumonia begins 4 to 6 hours after aspiration, lasts for 12 to 48 hours, and is characterized by infiltration of neutrophils into the alveoli and pulmonary interstitium. This inflammatory phase is characterized by ongoing vascular leakage of proteins with continued development of high-protein pulmonary edema, neutrophil sequestration and activation, and release of further proinflammatory cytokines. These first two stages constitute aspiration pneumonitis. The third phase, which constitutes the difference between aspiration pneumonitis and aspiration pneumonia, involves bacterial colonization of the airways and pulmonary parenchyma.

Predisposing Etiologies
Many conditions can increase the risk of aspiration and resultant pneumonia in dogs (Box 1). Dogs that have recently been heavily sedated or undergone general anesthesia are at risk for aspiration. Premedication with narcotics can result. Premedication with narcotics can

For more information, please see the companion article, “Aspiration Pneumonia in Dogs: Treatment, Monitoring, and Prognosis.”

Key Points
- Many conditions can predispose dogs to aspiration pneumonia.
- Preliminary diagnosis of aspiration pneumonia is based on history, physical examination, and thoracic radiography.
- Definitive diagnosis of aspiration pneumonia is based on culture of pulmonary exudate.
- Causative agents are often oropharyngeal commensal bacteria or enteric bacteria.

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after feeding.1 Other conditions such as vomiting or regurgitation increased risk of aspiration due to gastric distention and atony treatment with histamine type 2 (H2) blockers or proton pump inhibitors (PPIs) can lead to alkalinization of the gastric lumen and secondary colonization of the gastric lumen with enteric bacteria.16 Therefore, a greater potential for bacterial aspiration pneumonia may be present in patients receiving these medications.16

Preventive Measures
Numerous measures can be taken to prevent aspiration pneumonia in patients with a known risk factor. Preoperative fasting of patients, when possible, is recommended. However, the ideal length of the fast is debatable. Recent studies report that the historical 12- to 18-hour preanesthetic fast is not only unnecessary but also potentially harmful to patients.3,4 Shiun et al5 demonstrated that an 8-hour fast, with water up to 2 hours before anesthesia, is sufficient to minimize reflux during general anesthesia. Another study6 found that fasting for longer periods of time increased the acidity of the gastric environment, which would result in more severe pulmonary damage from reflux and aspiration. Patients at risk for aspiration should have their esophagus and stomach suctioned before extubation. Ensuring intact gag and swallow reflexes before extubation in patients undergoing anesthesia, especially those at risk for reflux or regurgitation, is imperative. If an episode of regurgitation or reflux is witnessed, the oropharyngeal cavity should be suctioned.

At-risk patients may benefit from prophylactic therapy to reduce the incidence of gastric reflux; however, reviews of this practice in both the human and veterinary literature are mixed. Metoclopramide at high doses was shown to significantly decrease the incidence of gastric reflux in canine patients premedicated with morphine that underwent general anesthesia.7 However, a more recent report8 found that neither ranitidine nor high-dose metoclopramide reduced the incidence of reflux in anesthetized dogs. Patients in the latter study were not premedicated with opioids; thus, the effectiveness of ranitidine and high-dose metoclopramide at minimizing the reflux caused by opioids was not evaluated in this study. The use of omeprazole, a potent PPI, has also been evaluated and shown to reduce gatroesophageal reflux in dogs undergoing anesthetic procedures when administered preoperatively.9 However, another study10 showed that esomeprazole, the S-isomer of omeprazole, failed to reduce the incidence of gastric reflux in dogs premedicated with hydromorphone and maintained with

### Box 1. Conditions Predisposing to Aspiration of Gastric Contents

<table>
<thead>
<tr>
<th>Large volumes of intragastric food/fluid</th>
<th>Nasogastric tube placement</th>
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</thead>
<tbody>
<tr>
<td>• Delayed gastric emptying</td>
<td>Foreign body obstruction</td>
</tr>
<tr>
<td>— Gastrointestinal motility disorders</td>
<td>• Impaired consciousness</td>
</tr>
<tr>
<td>— Ileus</td>
<td>— Sedation/general anesthesia</td>
</tr>
<tr>
<td>— Pyloric outflow obstruction</td>
<td>— Head trauma</td>
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<td>— Bowel obstruction</td>
<td>— Seizures</td>
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<td>— Pain</td>
<td>— Encephalopathy</td>
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<tr>
<td>— Anxiety</td>
<td>— Coma</td>
</tr>
<tr>
<td>— Opioid administration</td>
<td>• Impaired airway function</td>
</tr>
<tr>
<td>— Pregnancy</td>
<td>— Laryngeal or pharyngeal dysfunction or surgery</td>
</tr>
<tr>
<td>— Obesity</td>
<td>• Other</td>
</tr>
<tr>
<td>• Recent consumption of a meal</td>
<td>• Tracheostomy</td>
</tr>
<tr>
<td>• Enteral (via tube) overfeeding</td>
<td>• Gastric intubation</td>
</tr>
<tr>
<td>• Esophageal obstruction (foreign body, persistent right aortic arch, stricture)</td>
<td>• Cleft palate</td>
</tr>
<tr>
<td>• Esophageal dysmotility</td>
<td>• Weakness, paresis, or paralysis</td>
</tr>
<tr>
<td>— Megaesophagus</td>
<td>• Metabolic derangements (severe hypokalemia, hypomagnesemia)</td>
</tr>
<tr>
<td>— Myasthenia gravis or other peripheral neuropathy</td>
<td></td>
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<tr>
<td>— Reflux esophagitis</td>
<td></td>
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<tr>
<td>— Achalasia</td>
<td></td>
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<tr>
<td>• Gastroesophageal sphincter incompetence</td>
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Diagnosis

A presumptive diagnosis of aspiration pneumonia is based on the history, physical examination findings, and radiographic findings consistent with aspiration pneumonia. Often, the history includes a predisposing condition, but the actual aspiration event is usually not witnessed. The owner may report regurgitation, coughing, panting, or labored breathing. However, patients may present with nonspecific signs such as lethargy and poor appetite.

Dogs that aspirate while hospitalized may have an acute onset of labored breathing.

Physical examination findings often include fever, tachypnea, and/or dyspnea. Thoracic auscultation may reveal increased lung sounds, wheezes, crackles, or dull lung sounds. However, retrospective studies have demonstrated that 31% to 57% of dogs with aspiration pneumonia had a normal rectal temperature, 58% had a normal respiratory rate, and 28% to 31% had normal lung sounds at the time of diagnosis.

Thoracic radiography is the gold standard for preliminary diagnosis of aspiration pneumonia. Three-view radiographs are advised because multiple lung lobes may be involved. Interstitial, alveolar, and mixed pulmonary patterns may be evident. Diagnostic differentials for radiographic lung lobe consolidation are listed in Box 2. The lung lobe(s) involved depend on the position of the patient during the aspiration event; however, the right middle, right cranial, and left cranial lung lobes are most frequently affected. In most patients, more than one lung lobe is affected, with an average of 1.7 to 1.9 lung lobes involved in the disease process.

Cytology/Culture and Antimicrobial Sensitivity

Definitive diagnosis of aspiration pneumonia is made based on microbiologic cultures of exudate from the pulmonary airways. A tracheal wash (transtracheal or endotracheal), bronchoalveolar lavage (BAL), and bronchial brushing or biopsy are all means of sampling the pulmonary tract and airway secretions for cytology and culture.

A tracheal wash is easily performed, minimally invasive, inexpensive, and does not require specialized equipment. A transtracheal wash (TTW) can be performed in an awake or lightly sedated patient. Because the use of minimal or no sedation preserves the cough reflex, the patient is more likely to expectorate during the procedure, enhancing sample yield. An endotracheal wash (ETW) requires brief general anesthesia and hence may preclude coughing; however, coughage helps to mobilize secretions and hence may result in better sample collection.

ETW is more appropriate for patients that have coagulopathies or a conformation that makes the trachea difficult to isolate; are vomiting or regurgitating as the airway is secured during the procedure; or are aggressive. It also allows for gastric emptying before extubation in patients with compromised esophageal or laryngeal function or that are vomiting or regurgitating frequently.

Box 2. Common Differentials for Lung Lobe Consolidation

- Aspiration or bacterial pneumonia
- Neoplasia
- Pulmonary hemorrhage
- Granulomatous disease
- Lung lobe torsion

fentanyl infusions during orthopedic procedures, despite increasing the pH of refluxed fluids. Patients that received intravenous cisapride in addition to esomeprazole in this study did have a decreased incidence of reflux.

In a meta-analysis of controlled trials in human medicine, PPIs were found to be less effective than ranitidine at increasing gastric pH and to possibly increase gastric secretions, making reflux more likely; however, ranitidine has been shown to be ineffective at increasing gastric pH in dogs. In these studies, reflux was identified via pH probe placement in the caudal esophagus and/or stomach during anesthesia and was not directly witnessed (i.e., fluid was not seen coming from the mouth or nares).

Despite the controversy as to the effectiveness of H₂ blockers, PPIs, and prokinetics, little morbidity is associated with their use and the potential benefit associated with administration warrants consideration. As these medications are only used in the immediate perioperative period, there should be little risk of enteric bacterial colonization of the gastric lumen and subsequent risk for aspiration pneumonia, in theory.
Cell morphology is not well preserved in TTW/BAL samples, and the cells are fragile; therefore, fresh smears should be prepared within 30 minutes of collection. Direct smears of turbid fluid, cytocentrifuged samples, or mucus may provide the most information. These smears can be made by the blood smear or line smear technique; the latter may concentrate nucleated cells for analysis. To preserve cellular morphology, additional fluid samples should be placed in EDTA tubes and refrigerated before submission to a referral laboratory for analysis. A portion of the sample should also be placed in an appropriate culture medium and/or a
Clinical Pearls

- Patients may present with no signs referable to the respiratory tract.
- A history of a predisposing condition should alert the physician to the possibility of aspiration pneumonia.
- Tracheal washes are easy and inexpensive to perform.

Sterile tube. The sensitivity of transtracheal wash cultures has been reported at 50% to 90%, 27 77%, 28 and 44%. 13
Specificity has not generally been found to be as high, often due to contamination from the oral cavity. 27 To our knowledge, a comparison of diagnostic yield between ETW and TTW samples has not been performed. Even for patients in which antimicrobials have been initiated, culture and sensitivity testing of samples has been shown to be useful. 4 In the human field, sputum cultures and cultures of deep oral swabs are often used. 34 Recently, a study of use of deep oral swabs to obtain samples for culture and antimicrobial sensitivity testing was performed in puppies and adult dogs. 35 Swab samples were collected from the epiglottis after tracheal palpation and copugation, and results were compared with those obtained from samples collected by transternal tracheal wash. The cultures of the swab and tracheal wash were found to be similar in most of the adult dogs, but not the younger dogs. The results of this study suggest that deep oral swabs may be a useful diagnostic tool in dogs with hospital-acquired pneumonia, but further studies to investigate this diagnostic modality are needed.

Ancillary Diagnostics

Findings on routine blood work are neither sensitive nor specific for aspiration pneumonia; however, certain abnormalities are considered consistent with this condition. Leukocytosis or leukopenia, often with toxic changes present in the neutrophils, may be seen on a complete blood count (CBC), but a normal leukogram does not rule out pneumonia. A serum chemistry profile may be normal or may reflect comorbid disease. A 2008 study demonstrated elevations of liver enzymes and decreased albumin may be normal or may reflect comorbid disease. A 2008 study demonstrated elevations of liver enzymes and decreased albumin levels in more than half of 58 dogs with aspiration pneumonia. 28 A platelet count and coagulation profile are indicated before performing a TTTW to rule out a coagulopathy.

Pulse oximetry evaluates patient oxygenation status. Arterial blood gas analysis not only allows a more precise evaluation of patient oxygenation but also evaluates ventilation and acid/base status. These diagnostic tests help direct oxygen therapy and determine the potential need for positive-pressure ventilation.

Causative Agents

Bacterial agents of aspiration pneumonia are often commensals of the oropharyngeal cavity. 1 Dogs with aspiration pneumonia show a preponderance of Escherichia coli, Pasteurella, Staphylococcus, Streptococcus, Klebsiella, Enterococcus, and Mycoplasma infections as diagnosed by tracheal wash. 4, 25, 30 In most cases, infections are mixed, although single-agent infections can occur. 29 Anaerobic bacteria are rare unless pulmonary abscessation or a nidus of infection (e.g., food material) within the pulmonary tree exists.

References

### 1. Which of the following conditions must be met before an ETW is performed?
- a. The patient is anesthetized for the procedure.
- b. The patient is not receiving antimicrobial therapy.
- c. The patient is not regurgitating.
- d. The patient’s coagulation status is within normal limits.

### 2. Medical conditions that predispose dogs to aspiration pneumonia include
- a. polyarthritis.
- b. megaesophagus.
- c. hepatic insufficiency.
- d. heart disease.

### 3. The pulmonary pathology of aspiration pneumonitis/pneumonia includes
- a. bronchiolar dilation.
- b. low-protein pulmonary edema.
- c. decreased mucus production.
- d. stimulation of inflammatory mediators.

### 4. According to recent canine studies of preanesthetic fasting times, water can be offered up until _______ hour(s) before anesthetic induction.
- a. 1
- b. 2
- c. 3
- d. 4

### 5. Which history or physical examination finding is typically seen with aspiration pneumonia?
- a. sneezing
- b. diarrhea
- c. peripheral lymphadenopathy
- d. poor appetite

### 6. Common causative agents of aspiration pneumonia include
- a. *Bordetella bronchiseptica*.
- b. *Bartonella* spp.
- d. *Serratia* spp.

### 7. Which of the following lung lobes is classically affected in aspiration pneumonia?
- a. left caudal.
- b. right middle.
- c. right caudal.
- d. accessory.

### 8. The pathophysiology of aspiration pneumonitis includes which process?
- a. caustic damage from alkaline gastric pH
- b. necrosis of type II alveolar cells
- c. pulmonary hemorrhage
- d. extravasation of proteins into the pleural cavity

### 9. The etiologic agent(s) of aspiration pneumonia commonly
- a. are mixed.
- b. cause infection immediately after aspiration.
- c. are anaerobic.
- d. are oropharyngeal commensals in patients regularly treated with PPIs.

### 10. Which medication has been shown to reduce the incidence of gastric reflux in dogs under general anesthesia?
- a. maropitant
- b. prochlorperazine
- c. ondansetron
- d. metoclopramide