The term bronchiectasis is derived from the Greek words broncos, meaning windpipe, and ektasis, meaning stretching or extension. Bronchiectasis refers to chronic irreversible dilation of diseased bronchi. Bronchiectasis has many causes and should be considered the end stage of a number of mechanisms rather than a discrete disease entity. The condition can be the pulmonary manifestation of bronchial obstruction or untreated infection, diffuse pulmonary pathology, or a systemic disorder. Thoracic radiography and computed tomography (CT) have key roles in the identification of bronchiectasis. This article reviews the pathophysiology, clinical signs, diagnostics, and conditions associated with bronchiectasis.

PATHOPHYSIOLOGY

The respiratory tract has ciliated epithelium from the nasal cavity to the terminal bronchi-oles, and through a coordinated beat, the cilia clear the airways of mucus, inhaled particles, and cellular debris. Under conditions of prolonged inflammation or infection, the normal pulmonary clearance system becomes overwhelmed, and cellular debris, inflammatory cells, and mucus accumulate in the airways. As a result, destruction of the ciliated respiratory epithelium and submucosa occurs.

Impaired patient pulmonary clearance mechanisms initiate the classic pathway of bronchiectasis. As a consequence, mucosal secretions stagnate and endoluminal pressures rise, propagating an environment for infection. Once infection has been initiated, bacteria and pathogens remain in the bronchi for prolonged periods, inflaming the bronchial walls. Chronic infection and inflammation harm the respiratory epithelium and submucosa, predisposing patients to future infection. Thus the entire cycle repeats itself, causing further damage to the epithelium and submucosa and subsequent bronchial dilation (Figure 1). However, not all dogs with chronic infection or inflammatory lung disease develop bronchiectasis, indicating that preexisting abnormalities in immune and inflammatory host responses or the pulmonary clearance mechanism play a role in the development of bronchiectasis.

In all forms of bronchiectasis, the aforemen-
tioned dilation is identified in the proximal subdivisions of bronchi containing cartilaginous walls. This dilation is due to destruction of the elastic and muscular layers of the bronchial wall. The surrounding healthy lung tissue exerts a contractile force that expands the bronchi, creating the dilation, as observed via radiography. Subsequent bronchial wall thickening develops as a result of mucosal hypertrophy and hyperplasia. In chronic bronchiectasis, peribronchial alveolar tissue is damaged and fibrosis and/or squamous metaplasia occurs. Long-term inflammation obliterates distal bronchi and terminal bronchioles, reducing lung segmentation.

Bronchiectasis can be classified morphologically or spatially. Two morphologic forms are recognized in veterinary medicine and correspond to radiographic changes:

- **Cylindrical bronchiectasis**, the more common type, refers to uniform tubular dilation of proximal bronchial tree segments.
- **Saccular (cystic) bronchiectasis** is a balloon-like dilation of distal/terminal branch bronchi. The saccular form represents a more advanced manifestation of cylindrical bronchiectasis.

A single case report in the veterinary literature identified cystic bronchiectasis, which is considered the end stage of saccular bronchiectasis. Varicose bronchiectasis, a third form described in humans, consists of focally dilated bronchial segments interposed between normal or narrowed bronchial segments.

The spatial classification of bronchiectasis designates a focal, multifocal, or diffuse distribution pattern throughout the lungs. This categorization scheme aids in developing the differential diagnosis when attempting to determine the underlying cause. Causes of focal bronchiectasis include infection or obstruction, whereas diffuse causes indicate congenital or acquired deficiencies in host defense mechanisms.

### SIGNALMENT/CLINICAL SIGNS

Bronchiectasis is most common in old dogs (>10 years of age); however, an age range of 4 months to 18 years has been reported. The incidence of bronchiectasis is low, with 0.05% of dogs affected in a multicenter hospital population in a recent retrospective study. In comparing the incidence of bronchiectasis with other lower respiratory diseases, 10 of 109 (9.2%) cases of bronchiectasis were identified. Common diagnostic differentials identified with or without bronchiectasis included chronic bronchitis, bronchopneumonia, eosinophilic bronchopneumopathy, parasitic bronchitis, bronchial foreign body, and primary neoplasia. The most common breeds included the American cocker spaniel, miniature poodle, West Highland white terrier, Siberian husky, and English springer spaniel. Neutered males appear to be predisposed. Bronchiectasis is considered a rare manifestation of bronchial disease in cats, in which it occurs predominantly in old (i.e., >7 years of age), neutered males. The most common clinical sign is chronic coughing; other signs include tachypnea, dyspnea, and posttussive retching. A lack of clinical signs is less common.

### DIAGNOSTICS

Bronchiectasis is primarily an imaging diagnosis. Thoracic radiography, bronchography, and CT can be used to further delineate the location and type of
bronchiectasis. Imaging is essential in making a diagnosis and monitoring patient progress during treatment.

**Thoracic Radiography**

Thoracic radiography is considered the first-line diagnostic tool in bronchial disorders. However, it is relatively insensitive to early bronchial changes in humans. Early thoracic radiographic changes, such as peribronchial inflammation, which can obscure adjacent vessels, is often nonspecific for bronchiectasis. However, other radiographic changes are more apparent. Thickening and dilation of the bronchial walls appear as ring shadows (i.e., “doughnuts”) or tram tracks when seen end-on or longitudinally, respectively (Figure 2). “Honeycombing” describes a confluence of multiple thickened, dilated bronchi as seen via radiography. More advanced changes include roentgen signs, which parallel the previously described morphologic bronchiectatic changes. Cylindrical bronchiectasis is tubular dilation of the more proximal bronchial segments that fail to taper toward the periphery (Figure 3). The cylindrical form is by far the more common manifestation of bronchiectasis, representing 70% of cases in a recent retrospective study. The saccular form appears as multiple circumscribed outpocketings of distal and terminal bronchi and can be described as a “cluster of grapes” (Figure 4).

Additional nonspecific radiographic changes have been identified. Mixed pulmonary patterns (e.g., combinations of interstitial, bronchial, and alveolar pulmonary infiltrates; mucous plugs; atelectasis) often coincide with the previously described bronchiectatic changes (Figures 5 and 6). These radiographic changes are secondary to purulent or mucus-filled bronchi and extension into interstitial tissues. Mild narrowing or dilation of the trachea may be observed in some cases.

Spatial evaluation of bronchiectatic changes denotes the extent of bronchial pathology. Multiple-lobe involvement is more common (89%) than single-lobe disease. The right cranial lung is predisposed (i.e., affected in 93% of cases) to bronchiectatic changes. The predominance of this affected lobe is likely secondary to its craniocaudal location and to subsequent gravitational effects, which hamper clearance of bronchial exudates.
Bronchography

Bronchography, which entails administration of non-ionic water-soluble contrast via catheter or bronchoscope, was commonly performed to confirm the presence and extent of bronchiectasis. The dilated bronchial walls are coated with contrast, delineating their outline (Figure 7). However, with the advent of CT, bronchography is rarely performed today. Several complications are associated with bronchography, including decreased breathing capacity secondary to bronchial obstruction from contrast and alveolization of contrast, leading to granuloma formation and scarring. In humans, bronchography is considered nonessential unless surgical resection of the affected lung lobe(s) is recommended.

Computed Tomography

Evaluation of thoracic structures via CT has virtually replaced bronchography in diagnosing bronchiectasis in humans and animals. CT allows depiction of a “slice” (i.e., section) of the body free from superimposition of overlying structures. The computer assigns a gray-scale value to each pixel based on attenuation of the x-ray beam through tissue. With the advent of high-resolution CT, the specificity and sensitivity (i.e., 80% to 90%) of CT to diagnose bronchiectasis in humans are excellent. High-resolution CT uses a tightly collimated x-ray beam, decreased field of view, high spatial frequency algorithms, and thin slices (1 to 1.5 mm), rendering excellent spatial resolution. High-resolution CT enhances accurate identification of subtle pulmonary disease. In veterinary medicine, volumetric scanning with thinly collimated slices enables evaluation of the bronchial tree and adjacent pulmonary parenchyma.

Nonimaging Diagnostics

Adjunctive diagnostic tests are used for further evaluation of bronchiectasis. Bronchoalveolar lavage and transtracheal washes provide samples for cytologic and culture results. Cytologic analysis often demonstrates neutrophilic and eosinophilic inflammation and increased mucus. Bacterial cultures can guide future therapies and treat current infections. In humans, bronchiectatic sputum includes a large quantity of mucus and inflammatory cells with or without blood. Sputum samples are generally not taken in dogs because of excessive contamination from the oral cavity. In humans, hemoptysis commonly occurs because of ruptured anastomotic vessels bleeding into the bronchial lumen. The extensive anastomoses that occur between bronchial and pulmonary arteries secondary to chronic inflammation in humans do not occur in dogs. Consequently, hemoptysis is not a recognized finding in dogs with bronchiectasis.

ASSOCIATED CONDITIONS

As previously emphasized, bronchiectasis is associated with multiple conditions and warrants further diagnostics to determine the underlying cause. Local pulmonary disease, generalized pulmonary disorders, and systemic disease processes have been implicated and will be reviewed in this section.

Local Pulmonary Diseases

Local conditions most commonly include pulmonary infection by viral, bacterial, protozoal, parasitic, or fungal...
organisms. Recurrent or chronic pneumonia is the most common cause of bronchiectasis in both animals and humans.\textsuperscript{2,6,7,9,11} Incomplete treatment of pneumonia can lead to low-grade infection and exaggerated inflammatory response, which irreversibly damages bronchial walls.\textsuperscript{6} Endobronchial obstruction secondary to foreign bodies, broncholiths, or neoplasia is a less common cause of localized bronchiectasis. Bronchial foreign bodies, including inhaled grass awns and aspiration of teeth, have been reported.\textsuperscript{18,19} Broncholithiasis describes any calcified material within a bronchial lumen and includes extrusion of calcified adjacent lymph nodes and aspiration of calcified foreign material.\textsuperscript{20} Pulmonary neoplasms can arise from or invade the bronchial lumen or cause extraluminal compression, leading to bronchiectasis.\textsuperscript{2,6,7,11}

**Generalized Pulmonary Disorders**

Generalized pulmonary disorders affect the lung parenchyma diffusely and include chronic bronchitis, eosinophilic bronchopneumopathy, tracheal collapse (chondromalacia), and fibrotic pulmonary disease.

Spontaneous chronic bronchitis in dogs is poorly understood. The clinically accepted definition of chronic bronchitis is a chronic cough occurring for two consecutive months that is not attributable to another cause.\textsuperscript{11,12,21,22} The inciting cause is rarely elucidated, but inhaled irritants, recurrent low-grade infection, and smoldering inflammation have been implicated.\textsuperscript{12} As the disease progresses, irreversible pathologic changes caused by inflammation can occur in the bronchial walls, resulting in dilation of the bronchi.\textsuperscript{12,22} Chronic bronchitis and asthma are the most common systemic causes of bronchiectasis in cats.\textsuperscript{9}

Eosinophilic bronchopneumopathy, traditionally called *pulmonary infiltrates with eosinophilia*, is associated with eosinophilic infiltration of the lungs and bronchial mucosa.\textsuperscript{23–25} A wide range of disease entities varying from mild to severe in clinical presentation have been implicated and related to manifestations of immune hypersensitivity.\textsuperscript{23,24} The underlying causes of these exaggerated immune responses are not clearly understood in humans or animals. Suspected and known causes in humans and animals include fungi, molds, drugs, bacteria, and parasites.\textsuperscript{2,23} The inciting antigens are often unidentified. Heartworm infestation is the most common cause of eosinophilic bronchopneumopathy in animals.\textsuperscript{24,25} Alaskan malamutes and Siberian huskies are most frequently affected.\textsuperscript{25} Eosinophilic pul-

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**Figure 5.** Lateral projection of the thorax. **Cylindrical bronchiectasis** is identified in the right cranial and middle lobar bronchi (small arrows). A large mucus plug is noted in the terminal portion of the right cranial bronchus (large arrow).

**Figure 6.** Ventrodorsal projection of the thorax. **Focal dense interstitial pulmonary infiltrates** are noted in the midzone of the left caudal lung lobe (inset).
Pulmonary granulomatosis, which is considered a more severe form of eosinophilic bronchopneumopathy, is characterized by multiple lung nodules or masses with or without thoracic lymph node involvement. This condition is associated with more severe clinical signs and a poorer prognosis.

Chronic pulmonary fibrosis is defined as fibrosis of the lung interstitium and alveoli, with minimal changes to the bronchial walls, and is similar to idiopathic pulmonary fibrosis in humans. Multiple causes, including underlying connective tissue diseases, dust or inhaled irritants, and previous lung injury, have been identified. West Highland white, Parson Russell, Staffordshire bull, and cairn terriers are predisposed. Bronchiecasis is inconsistently found with chronic pulmonary fibrosis, which is progressive and fatal.

Tracheal collapse, which is characterized by flat, weak cartilaginous arcs and a flaccid tracheal membrane, is commonly found in miniature and chondrodystrophic breeds of dogs. This malformation has been described as chondromalacia or achondrodysplasia and is associated with a primary cartilage deficiency and dysplasia. The trachea and bronchial components containing cartilage dilate and narrow with inspiration and expiration, ultimately resulting in end-stage collapse. Bronchiecastic changes have been associated with this condition in humans. However, no such association in dogs has been firmly established, and whether chronic bronchial inflammation and bronchiecasis cause chondromalacia (or the reverse) warrants further study.

**Systemic Conditions**

Congenital or acquired impairment of host defenses is the underlying mechanism behind systemic conditions associated with bronchiecasis. These conditions include primary ciliary dyskinesis and primary immunodeficiencies.

Primary ciliary dyskinesis is a hereditary disorder characterized by absent or defective mucociliary clearance. This syndrome is associated with ultrastructural defects within the ciliary axonemes and appears to be a recessive autosomal inheritance defect. Electron microscopic findings include abnormal ciliary orientation and microtubular abnormalities with subsequent functional immotility. The impaired mucociliary clearance hinders one of the primary defense mechanisms of the res-
piratory system—trapping inhaled particulates and expectoration through ciliary action. As a consequence, secretions are retained, and recurrent infections develop, leading to bronchiectasis. A subset of patients with primary ciliary dyskinesis have Kartagener's syndrome, which is associated with a triad of signs: rhinosinusitis, bronchiectasis, and situs inversus. The incidence of this condition is well documented in humans—approximately half of all patients with primary ciliary dyskinesis have Kartagener's syndrome. The incidence in veterinary medicine is unknown.

Primary immunodeficiencies, predominantly the IgG subclass, rarely cause bronchiectasis in humans. An impaired IgG antibody response has been demonstrated in these patients when other underlying causes of bronchiectasis have been eliminated. In veterinary medicine, multiple primary immunodeficiencies have been identified. A canine-selective IgA and IgG deficiency similar to the condition in humans is typified by recurrent infections (i.e., usually upper respiratory infection, otitis, and dermatitis). These hereditary deficiencies have been established in the German shepherd, beagle, and shar-pei. Further investigation is needed to determine the incidence of canine primary immunodeficiencies and concurrent bronchiectasis.

**CLINICAL MANAGEMENT**

The clinical management of a patient with suspected bronchiectasis can be summarized as follows:

- Confirm a diagnosis of bronchiectasis
- Identify the cause, if possible
- Define the severity and location of disease
- Initiate treatment
- Monitor the patient

The foundations of therapy include administration of antibiotics when acute exacerbations of lung disease occur; treatment of underlying conditions; reduction of the inflammatory response through administration of corticosteroids; enhancement of bronchial clearance of secretions with physiotherapy, mucolytics, and bronchodilators; and surgical removal of diseased lung lobes. In humans, lung lobectomy is considered a palliative approach limited to patients who are resistant to medical therapy or who experience other complications, such as severe hemoptysis. Lung lobectomy is a therapeutic option in animals with focal bronchiectasis and may be curative. Treatment of recurrent bacterial infections is essential to disrupt the persistent cycle of host inflammatory response to pathogens and further damage to the bronchial walls. Dogs with pneumonia should be treated with broad-spectrum antibiotics efficacious against both aerobes and anaerobes. Culture and sensitivity test results can further guide the antibiotic choice. Airway samples for culture, sensitivity, and cytology may be obtained through bronchoalveolar lavage or transtracheal wash. Bronchoscopy with bronchoalveolar lavage is the preferred method to obtain samples. With bronchoscopy, the airways can be visually evaluated and samples can be obtained from the lower airways. Recurrent infections may be treated with chronic suppressive therapy or administration of antibiotics for 1 week each month. Bronchodilators may be beneficial; however, irreversible impaired airflow may limit their effectiveness. If inflammation resulting in some degree of bronchospasm is suspected, bronchodilator therapy may be beneficial. Cough suppressants should be avoided because they exacerbate the already decreased mucociliary clearance.

If the underlying disease is inflammatory in nature, antiinflammatory drugs are recommended. Corticosteroids are the most commonly prescribed antiinflammatory for inflammatory lung conditions. The use of systemic corticosteroids warrants caution because of pos-
Key Points

- Impaired pulmonary clearance mechanisms (e.g., stagnant mucosal secretions and bacteria) are the classic cause of bronchiectatic changes.
- The most common clinical sign reported in animals is chronic coughing.
- To initiate appropriate treatment of bronchiectasis, the underlying cause should be determined, if possible.

Bronchiectasis is a progressive condition, and the treatment goal is to maintain baseline radiographic changes for as long as possible. Saccular bronchiectasis is considered a more advanced form, and its radiographic presence indicates more severe disease. Because most patients are geriatric at diagnosis (median age: 12 years), the long-term prognosis for patients with bronchiectasis is generally fair to good, with a median survival time of 16 months. Thus early diagnosis of bronchiectasis is vital to treatment initiation, improved quality of life, and maximum survival time after diagnosis.

REFERENCES

ARTICLE #1 CE TEST

1. Bronchiectasis is
   a. a distinct disease entity.
   b. a pulmonary manifestation of an underlying disorder.
   c. transient and reversible as documented via radiography.
   d. always associated with pneumonia.

2. Saccular bronchiectasis is
   a. a more advanced form of bronchiectasis.
   b. associated only with local disease conditions.
   c. identifiable via radiography by its “cluster of grapes” appearance.
   d. a and c

3. The ________ lung lobe is most often affected by bronchiectasis.
   a. right middle
   b. left caudal
   c. right cranial
   d. right caudal

4. The advantage(s) of CT in diagnosing bronchiectasis include(s)
   a. increased sensitivity in detecting early pulmonary changes.
   b. depiction of a section of the body free from superimposition of overlying structures.
   c. decreased morbidity compared with that associated with bronchography.
   d. all of the above

5. Which clinical finding is not associated with bronchiectasis in animals?
   a. coughing
   b. hemoptysis
   c. dyspnea
   d. posttussive retching

6. Which is a hereditary disorder characterized by the absence of defective mucociliary clearance?
   a. chondromalacia
   b. chronic pulmonary fibrosis
   c. primary ciliary dyskinesis
   d. IgG subclass immunodeficiency

7. The most common cause of eosinophilic bronchopneumopathy is
   a. heartworm disease.
   b. inhaled allergens.
   c. drug reaction.
   d. fungal infection.

8. Clinical management of bronchiectasis involves
   a. diagnosis of the underlying cause.
   b. definition of the severity and location of disease.
   c. monitoring the patient.
   d. all of the above

9. Local conditions, such as pneumonia, that cause bronchiectasis
   a. are more common than systemic conditions.
   b. occur equally in dogs and cats.
   c. are usually associated with broncholithiasis.
   d. are less common than systemic conditions.

10. Which is not associated with Kartagener’s syndrome?
    a. situs inversus
    b. hydrocephalus
    c. rhinosinusitis
    d. bronchiectasis

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