THORACIC RADIOGRAPHIC CHARACTERISTICS OF CANINE INFLUENZA VIRUS IN SIX DOGS

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Canine influenza virus is an emerging, highly contagious, respiratory pathogen that has not previously been radiographically described. In this retrospective case series study, we describe the thoracic radiographic appearance of confirmed canine influenza virus in six dogs. Radiographic findings varied, but included abnormal unstructured interstitial (one) and unstructured interstitial and alveolar (five) pulmonary patterns, which were distributed cranioventral (four), diffuse (one), and caudodorsal (one). The right middle (five), left cranial (five), and right cranial (four) lung lobes were most commonly affected. Additionally, mild pleural effusion was present in one dog. Intrathoracic lymphadenopathy and cranial mediastinal widening/fluid accumulation were not detected in any dog. Canine influenza virus should be considered as a differential diagnosis for canine patients with respiratory signs and a cranioventral unstructured interstitial to alveolar pulmonary pattern.

Key words: canine, influenza, radiographs, virus.

Introduction

CANINE INFLUENZA VIRUS is a type A influenza virus that was first identified in greyhounds in 2004.[1] Since then the virus has been responsible for disease outbreaks across the United States of America, not only in racing greyhounds, but also in the pet population with the virus now identified in 40 states and the District of Columbia.[2] The virus has also been documented in Korea, China, and Thailand.[2] Like other viruses, it is spread via aerosolized respiratory secretions as well as contaminated objects and people.[2] As this is an emerging pathogen, all dogs are susceptible to infection with a morbidity rate of 80% and mortality rate of less than 10%.[2]

The infection has a 2- to 4-day incubation period after which affected dogs may begin to show nonspecific signs of respiratory disease.[1] While a paucity of published scientific data exists on the clinical aspects of the disease, previously reported clinical signs include lethargy, anorexia, weight loss, fever, nasal discharge, ocular discharge, and a cough.[1] Documented gross and histopathologic postmortem findings vary depending on the severity of disease, but include cranioventral lung consolidation, atelectasis, pulmonary hemorrhage, pleural effusion (hemorrhage), mediastinal hemorrhage, alveolar septal thickening due to edema or inflammatory cell infiltration, loss of ciliated epithelial cells, pyogranulomatous to lymphoplasmacytic pulmonary infiltrates, and vasculitis.[1] More severe lung involvement is thought to be due to concurrent secondary bacterial or *Mycoplasma* spp. infections.[1]

To our knowledge there are no scientific reports detailing the radiographic features of canine influenza. The purpose of this report is to describe thoracic radiographic characteristics in a sample of dogs with confirmed canine influenza virus.

Methods

In this retrospective case series study, the electronic medical records at the University of Georgia's Veterinary Teaching Hospital were searched for dogs of any age, breed, or sex with a confirmed diagnosis of canine influenza virus and thoracic radiographs between January 1, 2004 and July 1, 2015. Three-view (left-right lateral, right-left lateral, and ventrodorsal) thoracic radiographs obtained at the time of diagnosis were required to be included in the study. Dogs were excluded from the study if they were diagnosed with concurrent nonrespiratory thoracic disease or did not have diagnostic three-view thoracic radiographs available for review. For each dog, the signalment (age, breed, sex), history, and method of diagnosis were recorded from the medical record by board-certified veterinary radiologist (S.S.). The results of any additional respiratory diagnostics and

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method of sample collection were also recorded. Thoracic radiographs were independently reviewed by two board-certified veterinary radiologists (S.S., A.S.) using dedicated image-viewing software (Osirix, Pixmeo, Geneva, Switzerland). The results of independent reading sessions were compared and, where disagreement occurred, a consensus opinion was generated. Reviewers were aware of the patient's diagnosis and allowed to adjust contrast and brightness of the images as would be done in the clinical setting. Radiographic characteristics recorded were the following: presence of lymphadenopathy, pleural effusion, cranial mediastinal widening/fluid accumulation, and abnormal pulmonary patterns. If present, pleural effusion was graded as mild (minimal displacement the lung lobes), moderate (heart and diaphragm partially obscured), or severe (heart and diaphragm completely obscured). Abnormal pulmonary patterns were classified as unstructured interstitial, structured/nodular interstitial, bronchial, and alveolar. The distribution of the abnormal pulmonary patterns was recorded as cranioventral, perihilar, caudodorsal, or diffuse. If diffuse, the changes were further subclassified as symmetric or asymmetric. The specific lung lobes affected were also recorded.

Results

Six dogs were identified that met the inclusion criteria with no dogs excluded. All six were diagnosed with canine influenza virus via positive polymerase chain reaction. Represented breeds were three mixed breeds and one of each of the following: Chow Chow, Beagle and St. Bernard. Dogs ranged in age from 5 to 12 years with a median of 9 years. There were four neutered males and two spayed females. Five of the six dogs presented for coughing, while one dog presented for lethargy and shallow breathing. Four dogs had a history of recently visiting a boarding/daycare facility with two dogs having known direct contact with dogs subsequently diagnosed with canine influenza virus. In regards to additional respiratory diagnostics, three of six patients were diagnosed with concurrent *Mycoplasma* pneumonia based on a positive polymerase chain reaction via a transtracheal wash (1) or pharyngeal swab (2). All six dogs had a respiratory polymerase chain reaction panel which, in addition to canine influenza virus and Mycoplasma, also tested for Bordatella bronchiseptica, canine adenovirus 1 and 2, canine distemper virus, and coronavirus; all of which were negative.

Reviewers identified abnormalities on all thoracic radiographic studies, which were obtained using a portable X-ray generator (MinXray HF8015, MinXray Inc., Northbrook, IL) and digital radiography system (Eklin Mark V, Sound Eklin, Carlsbad, CA) using a technique of 74–88 kV, 50 mA, and 0.15 s. While none of the dogs had radiographically apparent lymphadenopathy or cranial mediastinal widening/effusion, one dog was identified with pleural effusion, which was graded as mild. This dog was also positive for *Mycoplasma*. One dog had an unstructured interstitial pattern, while the remaining five dogs had two pulmonary patterns present, unstructured interstitial and alveolar (Fig. 1). No dog was identified with a structured interstitial or bronchial pattern. The distribution of the pulmonary patterns was cranioventral in four dogs, diffuse in one, and caudodorsal in one. None of the dogs had a perihilar distribution. The one dog with a diffuse pulmonary pattern was further classified as asymmetric being more severe in the right lung lobes (Fig. 2). The dog with a caudodorsal distribution of an unstructured interstitial pattern had a cranioventral alveolar pattern on follow up thoracic radiographs 3 days later. No other dog had follow up radiographs for comparison. In all dogs, multiple lung lobes were affected. The left cranial, left caudal, right cranial, right middle, and right caudal lungs were affected in two dogs; one with a cranioventral distribution, and another with a diffuse distribution. Two dogs had abnormal pulmonary patterns in the right cranial, right middle, and left cranial lung lobes; both with a cranioventral distribution. The right middle and left cranial lung lobes were affected in one dog with a cranioventral distribution. The caudodorsal unstructured interstitial pattern affected the right and left caudal lung lobes in one dog.

Discussion

In this study, the thoracic radiographic characteristics identified in dogs with canine influenza virus were variable. The most commonly observed characteristics were a cranioventral distribution of unstructured interstitial and alveolar patterns, with multiple lung lobes affected. Canine influenza virus should therefore be considered as a differential diagnosis in canine patients with these characteristics.

In this sample of six dogs, it is unknown whether age, breed, or sex could have been risk factors for developing clinical signs. All included dogs in this study were middle aged or older. All six dogs had presenting clinical signs of nonspecific respiratory disease including those previously documented with canine influenza virus.[1] In addition, all dogs in this study were pets with a recent history of either visiting a boarding/daycare facility (four dogs) or having direct contact with dogs subsequently diagnosed with canine influenza virus (two dogs) thus making transmission of the disease more likely.

Three of the six dogs had concurrent *Mycoplasma* spp. pneumonia diagnosed via polymerase chain reaction on fluid from either a transtracheal wash or pharyngeal swab. Secondary bacterial or mycoplasma infections have been documented in dogs with more severe canine influenza

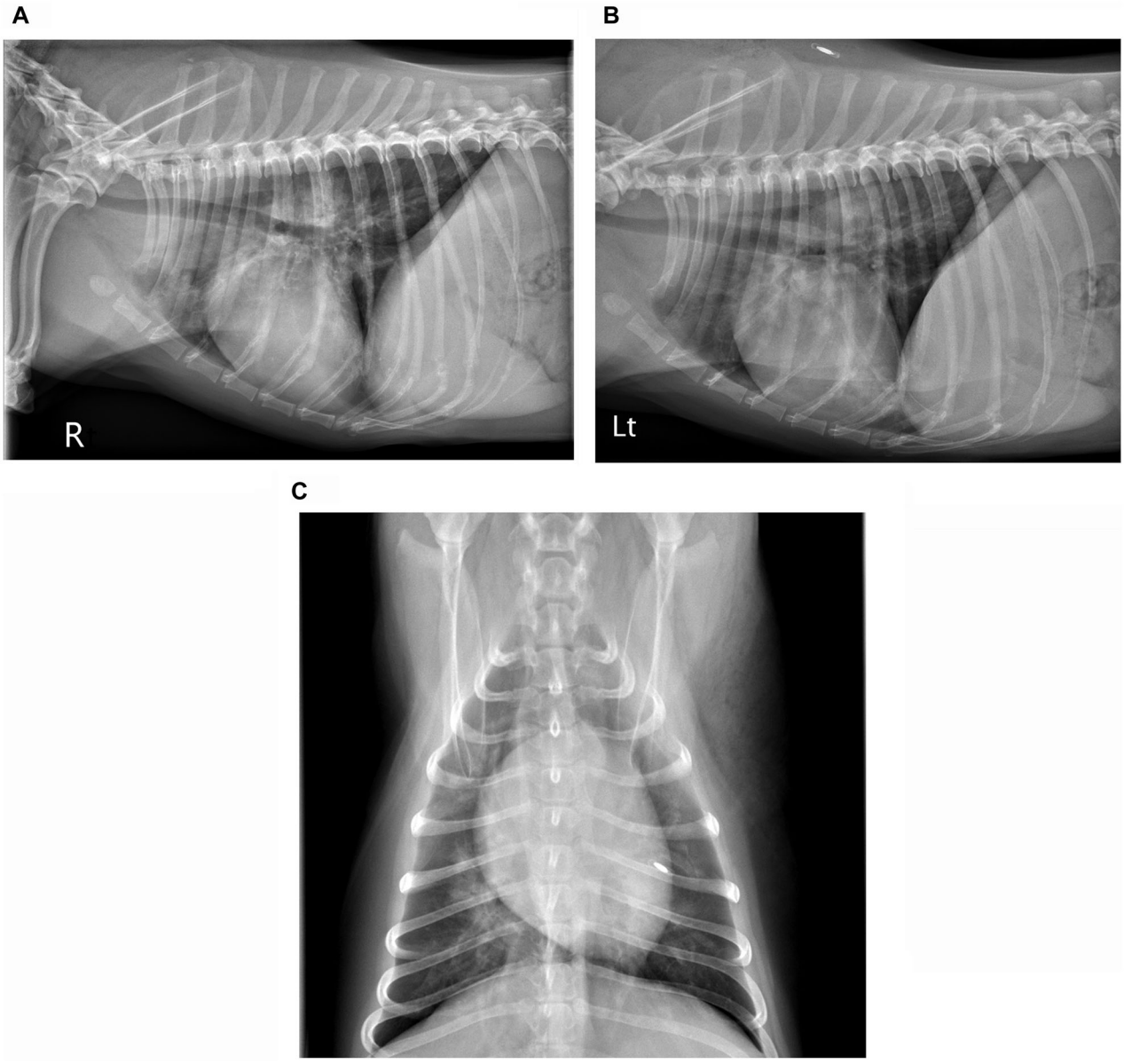

FIG. 1. Left-right lateral (A), right-left lateral (B), and ventrodorsal (C) radiographs of an 11-year-old mix breed dog with canine influenza virus and an unstructured interstitial (left cranial lung lobe) to alveolar (right middle lung lobe) pulmonary pattern.

virus,[3,4] however all dogs in this study survived to discharge consistent with the previously noted low mortality rate.[2] While a normal inhabitant of the canine upper respiratory tract, *Mycoplasma* spp. have been documented as a primary cause of pneumonia or as a coinfection.[5–8] It is unknown if the positive polymerase chain reaction results for *Mycoplasma* in two of the three dogs in this study indicated true disease or normal flora based on sample location (pharyngeal). Thus possible effects of coinfection with *Mycoplasma* spp. on the radiographic findings in this sample of dogs remain unclear. A prior case series of 17 dogs with *Mycoplasma* spp. pneumonia identified a variety of radiographic changes including pleural effusion; tracheal collapse; and interstitial, bronchial, alveolar, and mixed pulmonary patterns.[5]

Radiographically, lymphadenopathy, and mediastinal widening/effusion were not identified in any of the dogs. Mild pleural effusion was noted in one dog. While lymphadenopathy, mediastinal fluid/hemorrhage, and pleural effusion have been reported in dogs with pneumonia, it is unknown whether these findings are related to the underlying infectious agent, duration of infection or other patient factors.[5,9] Pulmonary patterns identified in this study are consistent with prior studies that suggest interstitial and

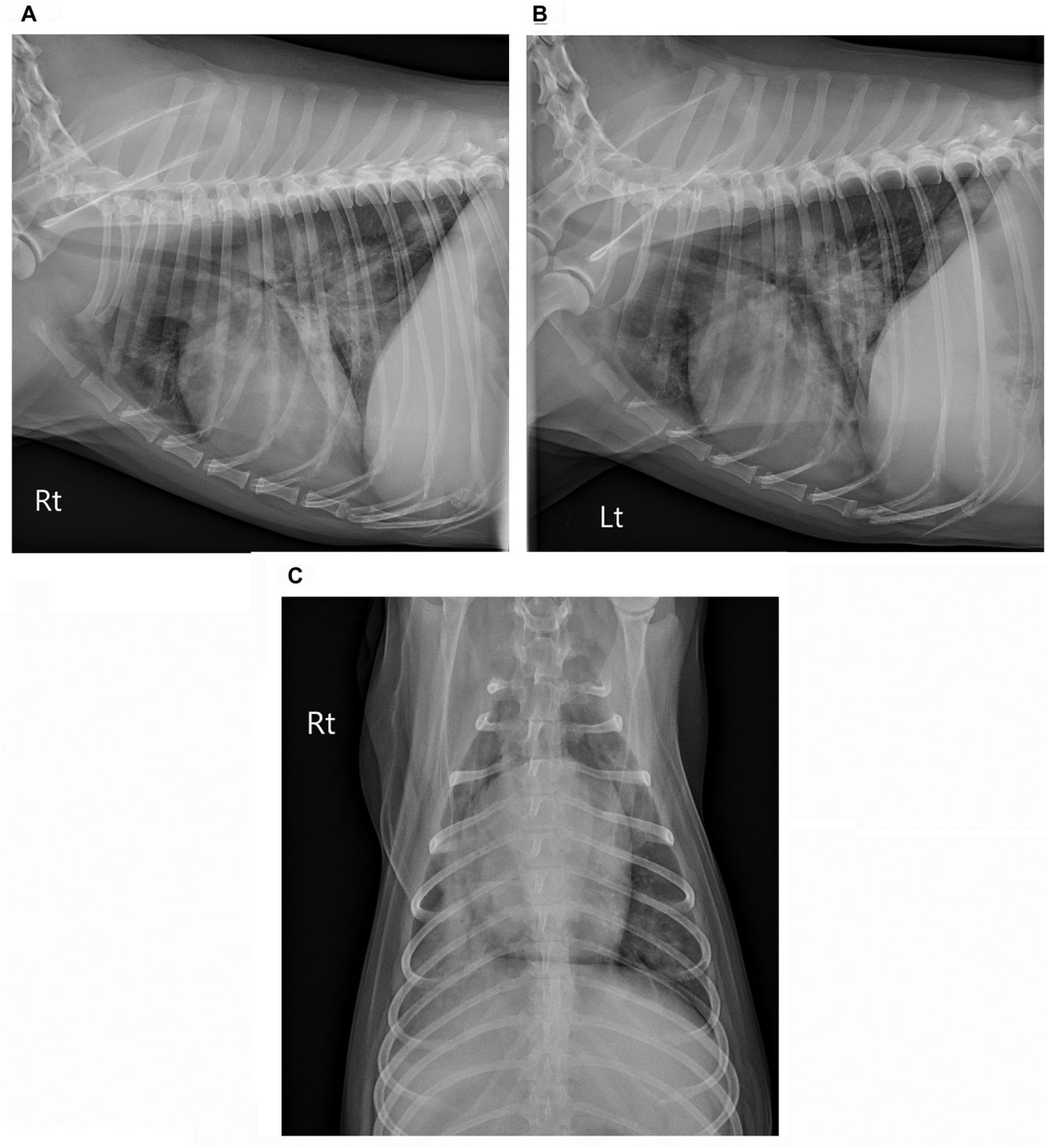

FIG. 2. Left-right lateral (A), right-left lateral (B), and ventrodorsal (C) radiographs of an 8-year-old mix breed dog with canine influenza virus and a diffuse, asymmetric distribution of pulmonary changes, which is more severe in the right lungs.

alveolar are the most common pulmonary patterns for both bacterial and viral pneumonia.[6,9,10,12–14] It has been noted that pulmonary changes initially start as an interstitial pattern and, as the disease progresses, the pattern becomes alveolar.[10,12] The progression of disease would explain why both interstitial and alveolar patterns were identified in all but one dog in this study. The one dog in this study with an initial unstructured interstitial pattern did however go on to develop an alveolar pattern on follow up radiographs 3 days later.

A cranioventral distribution of the pulmonary patterns was most common (four dogs), with one having diffuse

asymmetric changes and another with a caudodorsal distribution. This is consistent with prior studies that suggest dogs with bacterial pneumonia or with viral and bacterial coinfections, including *Mycoplasma* spp. have radiographic findings similar to aspiration pneumonia, in that the pulmonary changes are most common in the cranioventral aspect of the lungs.[6,13] This is thought to be due to the effects of gravity on the causative organism.[14] A diffuse distribution of abnormal pulmonary patterns has been thought to suggest more severe disease,[10,12] or viral pneumonia.[13] The patient with a caudodorsal distribution of the abnormal pulmonary pattern had a cranioventral distribution on follow-up radiographs 3 days later and thus the difference may be due to the duration or severity of disease. This is the same dog that had only an unstructured interstitial pattern.

In all dogs, multiple lung lobes were affected with the right middle (five dogs), left cranial (five dogs) and right cranial (four dogs) lung lobes being most common. This is similar to dogs with aspiration pneumonia and both bacterial and viral pneumonia, as multiple lung lobes are usually affected, specifically the right middle, right cranial and left cranial lung lobes.[6,14] No dog in this study had a history or documented clinical signs of vomiting/regurgitation and thus aspiration pneumonia was thought to be unlikely, but can not be completely ruled out.

The primary limitation of this study was the retrospective design. This prohibited follow-up thoracic radiographic studies from being obtained in all patients and correlation with clinical response. In addition, some infected dogs may not have been tested for canine influenza virus and thus not included in the study. Another limitation was the small number of dogs identified for inclusion, which precluded analysis of possible covariants such as age, sex, breed, or concurrent diseases. Larger prospective studies are recommended to further evaluate the thoracic radiographic appearance of canine influenza virus and to assess any correlations with clinical response.

In conclusion, canine influenza virus should be included as a differential diagnosis in canine patients with unstructured interstitial and alveolar pulmonary patterns. While viral pneumonias may have been reported to have a caudodorsal, diffuse, or cranioventral distribution; this study would suggest that a cranioventral unstructured interstitial to alveolar pattern may be common in dogs affected by canine influenza virus.

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Category 2

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(b) Revising Article for Intellectual Content
Scott Secrest and Ajay Sharma

Category 3

(a) Final Approval of the Completed Article
Scott Secrest and Ajay Sharma

REFERENCES

1. Crawford PC, Dubovi EJ, Castleman WL, et al. Transmission of equine influenza virus to dogs. Science 2005;310:482–485.

2. American Veterinary Medical Association [Internet] 2015. Schaumburg: The Association. Available from: http://www.avma.org/KB/Resources/Reference/Pages/Canine-Influenza-Backgrounder.aspx.

3. Dubovi EJ. Canine influenza. Vet Clin North Am Small Anim Pract 2010;40:1063–1071.

4. Dubovi EJ, Njaa BL. Canine influenza. Vet Clin North Am Small Anim Pract 2008;38:827–835.

5. Chandler JC, Lappin MR. Mycoplasma respiratory infections in small animals: 17 cases (1988-1999). J Am Anim Hosp Assoc 2002;38:111–119.

6. Viitanen SJ, Lappalainen A, Rajamaki MM. Co-infections with respiratory viruses in dogs with bacterial pneumonia. J Vet Intern Med 2015;29:544–551.

7. Armstrong D, Morton V, Yu B, et al. Canine pneumonia associated with mycoplasma infection. Am J Vet Res 1972;33:1471–1478.

8. Rosendal S. Canine mycoplasmas: pathogenicity of mycoplasmas associated with distemper pneumonia. J Infect Dis 1978;138:203–210.

9. Norris CR, Griffey SM, Samii VF, et al. Comparison of results of thoracic radiography, cytologic evaluation of bronchoalveolar lavage fluid, and histologic evaluation of lung specimens in dogs with respiratory tract disease: 16 cases. J Am Vet Med Assoc 2001;218:1456–1461.

10. Dear JD. Bacterial pneumonia in dogs and cats. Vet Clin Small Anim 2014;44:143–159.

11. Myer W. Radiography review: the interstitial pattern of pulmonary disease. Vet Radiol 1980;21:18–23.

12. Myer W. Radiography review: the alveolar pattern of pulmonary disease. Vet Radiol 1979;20:10–14.

13. Kogan DA, Johnson LR, Jandrey KE, Pollard RE. Clinical, clinicopathologic and radiographic findings in dogs with aspiration pneumonia: 88 cases (2004-2006). J Am Vet Med Assoc 2008;233:1742–1747.

14. Tart KM, Babski DM, Lee JA. Potential risks, prognostic indicators, and diagnostic and treatment modalities affecting survival in dogs with presumptive aspiration pneumonia: 125 cases (2005-2008). J Vet Emerg Crit Care 2010;20:319–329.