

RADIOGRAPHIC APPEARANCE OF CONFIRMED PULMONARY LYMPHOMA IN CATS AND DOGS

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Herein we describe the thoracic radiographic appearance of confirmed pulmonary lymphoma. Patients with thoracic radiographs and cytologically or histologically confirmed pulmonary lymphoma were sought by contacting American College of Veterinary Radiology members. Seven cats and 16 dogs met the inclusion criteria, ranging in age from 4 to 15 years. Method of diagnosis was via ultrasound-guided cytology (four), surgical biopsy (two), ultrasound-guided biopsy (one), and necropsy (16). Radiographic findings varied but ranged from normal (one) to alveolar (six) and/or unstructured interstitial infiltrates (11), nodules and/or masses (eight), and bronchial infiltrates (four). Additional thoracic radiographic findings included pleural effusion and lymphadenopathy. The results of this evaluation indicate a wide variability in thoracic radiographic abnormalities in cats and dogs with pulmonary lymphoma. © 2010 *Veterinary Radiology & Ultrasound*

Key words: cat, dog, pulmonary lymphoma, radiography.

Introduction

LYMPHOMA IS COMMON in the cat and dog, accounting for approximately 33% of all feline and approximately 7–24% of all canine tumors.^{1,2} Lymphoma can affect many organs; the most frequent being the feline gastrointestinal tract and the canine lymphoreticular system.^{1,2} Lymphoma can involve the lungs as a primary disease or secondary to multicentric or extranodal lymphoma.^{1,2}

Primary pulmonary lymphoma is rare in humans, representing <1% of all lymphoma.³ In humans, the criteria for diagnosis of primary pulmonary lymphoma are strict: the lung or bronchus is involved, without evidence of mediastinal lymphadenopathy or extrathoracic lymphoma at initial presentation, or for 3 months following diagnosis.³ In humans, primary lymphoma lesions are centered on the airways, often contain air bronchograms, and occasionally result in bronchial dilation. Nodules, masses, and areas of consolidation are the most frequently reported patterns.^{3–5} Histologically, malignant lymphocytes have a preferential peribronchovascular distribution.^{4,5}

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In humans, the prevalence of secondary pulmonary involvement is 4–12% at initial presentation and 30–40% during the course of the disease.³ Pulmonary infiltrates in humans due to secondary pulmonary lymphoma are varied. Nodular, bronchovascular, alveolar, and a miliary interstitial pattern have all been reported. Additionally, thoracic lymphadenopathy and pleural effusion are common in secondary pulmonary lymphoma.^{3,6–8}

Primary pulmonary lymphoma has not been described in the dog. However, based on bronchoalveolar lavage and histology, approximately 66% of dogs with multicentric lymphoma have pulmonary involvement.^{9,10} It has been reported that 29.6–37% of dogs with multicentric lymphoma have abnormal pulmonary infiltrates on thoracic radiographs; however, these reports did not confirm pulmonary involvement and/or specifically describe the radiographic findings.^{9,11–13} Pulmonary patterns that have been described in cats and dogs with presumed pulmonary lymphoma are unstructured interstitial, reticulo-nodular, alveolar, and nodular.^{12,14–18} There are no data regarding the prevalence of abnormal pulmonary infiltrates in cats with lymphoma.

To our knowledge, reports specifically describing the radiographic appearance of cytologically or histologically confirmed pulmonary lymphoma in the cat and dog are limited to a few individual reports.^{15–18} The purpose of this report is to describe the radiographic appearance of confirmed pulmonary lymphoma in 23 cats and dogs.

Materials and Methods

Examples of confirmed pulmonary lymphoma were requested via emailing American College of Veterinary

Radiology members. Submitted material spanned 1998–2009. Inclusion criteria were a thoracic radiographic examination and definitive cytologic or histologic diagnosis of pulmonary lymphoma. Species, age, gender, breed, history, and method of diagnosis were tabulated.

Thoracic radiographs were reviewed by a board-certified radiologist (J.K.R.). Radiographs were evaluated for an abnormal pulmonary pattern, lymphadenopathy, and pleural effusion. Abnormal pulmonary patterns were classified as unstructured interstitial, alveolar, bronchial, and nodules and/or masses. The distribution of unstructured interstitial, alveolar, and bronchial infiltrates were classified as diffuse if the entire lung was abnormal and focal or multifocal if one or more parts of the lung were abnormal. In patients with a diffuse pulmonary pattern, the distribution was further classified as symmetric or asymmetric. Pleural effusion was considered mild if there was minimal displacement of the lung lobes, moderate if the heart and diaphragm were partially obscured, and severe if the heart and diaphragm were completely obscured.

Twenty-three examples of confirmed pulmonary lymphoma were collected. There were seven cats and 16 dogs. Patients ranged from 4 to 15 years of age, with a mean of 7.9 years and a median of 7 years. Thirteen patients were neutered females and 10 were neutered males. Breeds consisted of Scottish Fold cat (one), Domestic Shorthair cat (three), and Domestic Longhair cat (three), Labrador Retriever (three), Golden Retriever (two), Shar Pei (one), Bernese Mountain Dog (one), Pug (one), English Bulldog (one), Doberman Pinscher (one), Great Dane (one), Australian Shepherd (one), West Highland White Terrier (one), Beagle (one), Kooikerhondje (one), and Scottish Terrier (one). Five patients (22%) had only respiratory signs, with the remaining having a variety of nonspecific signs.

All patients had thoracic radiographs within 0–23 days of definitive diagnosis, with a mean of 4.4 days and a median of 2 days. Eighteen (78%) patients had thoracic radiographs within 1 week of definitive diagnosis. Lym-

phoma was diagnosed in all lung samples. The method of diagnosis consisted of ultrasound-guided needle aspiration (four), surgical biopsy (two), ultrasound-guided biopsy (one), and necropsy (16). Lymphoma was phenotyped in six patients; four were T-cell and two were B-cell lineage.

Eighteen of 23 patients (78%) had lymphoma confirmed elsewhere in the body.

Results

One dog had normal thoracic radiographs. An unstructured interstitial pattern was seen in 11 of 23 patients (one cat and 10 dogs; Fig. 1), an alveolar pattern in six of 23 patients (one cat and five dogs; Figs 2 and 3), nodules and/or masses in eight of 23 patients (three cats and five dogs; Figs 4 and 5), and a bronchial pattern in four of 23 patients (three cats and one dog; Fig. 5). Nine patients (39%) had more than one pulmonary pattern identified. An unstructured interstitial pattern was seen in combination with a bronchial pattern in three patients, with an alveolar pattern in three patients, and with nodules and/or masses in one patient. A bronchial pattern was seen in combination with nodules and/or masses in one patient.

The distribution of interstitial, alveolar, and bronchial infiltrates was diffuse and symmetric in seven patients, diffuse and asymmetric in eight patients, and focal in one patient. In the patient with a focal distribution, an alveolar pattern was present in the cranial segment of the left cranial lung lobe (Fig. 3). The severity of pulmonary infiltrates was mild in four patients, moderate in seven patients, and severe in five patients. Of the eight patients with nodules and/or masses, five patients had a solitary lesion, one patient had two lesions, and two patients had greater than three lesions. Radiographic pulmonary patterns were not correlated with specific organ involvement or phenotype.

Additional thoracic radiographic findings included pleural effusion in three patients (two cats and one dog; Fig. 3) and thoracic lymphadenopathy in five patients (one cat and

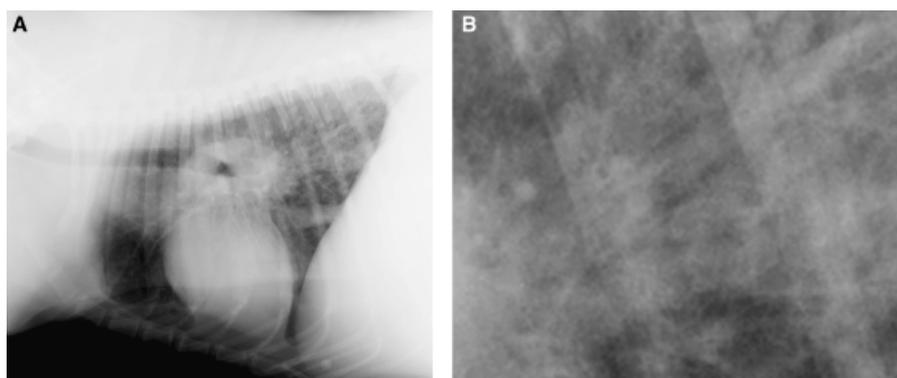


FIG. 1. (A) Left lateral thoracic radiograph of a 4-year-old Labrador Retriever with a moderate bronchointerstitial pattern and sternal and hilar lymphadenopathy. (B) Close up image of the dorsocaudal lung highlighting the bronchointerstitial infiltrate. At necropsy 2 days later, lymphoma was diagnosed in the lungs, lymph nodes, liver, spleen, kidneys, and bone marrow.



FIG. 2. Left lateral thoracic radiograph of a 7-year-old Australian Shepherd with a severe, patchy interstitial to alveolar pattern most severe in the caudal lungs. At necropsy 2 days later, lymphoma was diagnosed in the lungs, lymph nodes, spleen, small intestines, kidneys, bladder, and bone marrow.

four dogs; Fig. 1). The pleural effusion was classified as severe in two patients and moderate in one patient, and was bilateral and symmetrical in all three patients. Of the patients with thoracic lymphadenopathy, one patient had sternal lymphadenopathy, two patients had cranial

mediastinal lymphadenopathy, and five patients had hilar lymphadenopathy.

Discussion

In cats and dogs with confirmed pulmonary lymphoma, the abnormalities varied greatly, ranging from normal and a mild unstructured interstitial pattern to alveolar disease and pulmonary masses. The most common radiographic pulmonary pattern in dogs was an unstructured interstitial infiltrate, followed by masses and/or nodules, alveolar infiltration, and bronchial infiltration. This is consistent with previous reports in which an unstructured interstitial infiltrate has been reported as the most common radiographic pulmonary pattern in canine multicentric lymphoma.¹² In cats, the most common radiographic pulmonary pattern was pulmonary masses and/or nodules and a bronchial infiltrate. Metastatic pulmonary nodules have been described in cats with lymphoma^{17,18}; one in a 9-year-old, male neutered Abyssinian with epitheliotrophic T-cell gastrointestinal lymphoma with metastasis to the lung and skeletal muscle. The pulmonary metastasis was classified as a solitary, well-demarcated mass.¹⁷

The pathophysiology and histologic appearance of pulmonary lymphoma may explain the variation in radiographic pulmonary patterns observed with this neoplasm. Depending on the origin, pulmonary lymphoma can be

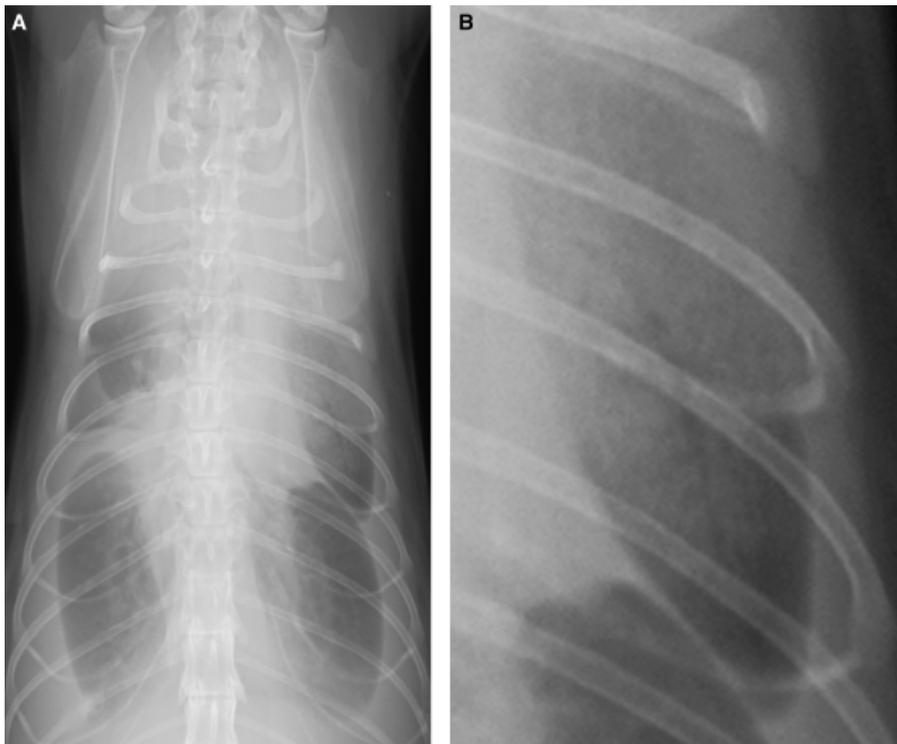


FIG. 3. (A) Ventrodorsal thoracic radiograph of a 6-year-old Domestic Shorthair cat with severe pleural effusion and an alveolar pattern in the cranial portion of the left cranial lung lobe. (B) Close up image of the left cranial lung lobe. Torsion of the left cranial lung lobe was diagnosed at surgery 2 days following thoracic radiographs; histology confirmed lymphoma in the lung and pleural space.

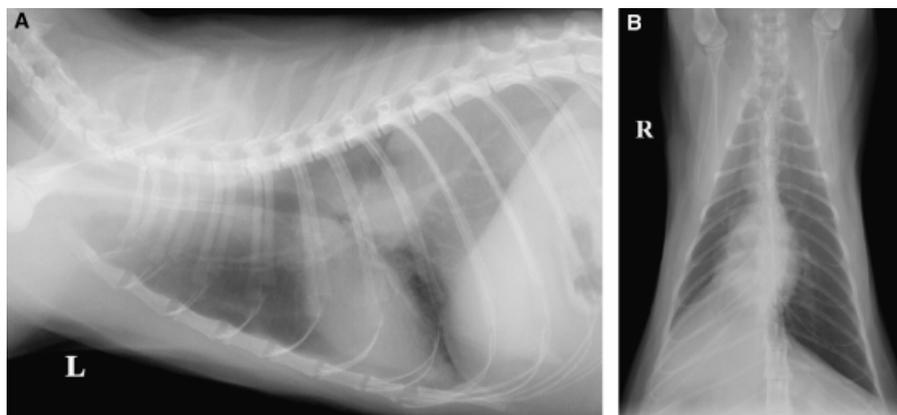


FIG. 4. (A) Left lateral thoracic radiograph of a 6-year-old Domestic Longhair cat with a mass in the right caudal lung lobe. (B) Ventrodorsal thoracic radiograph of the same patient. Three days following thoracic radiographs surgery was performed to remove the right caudal lung lobe and pulmonary lymphoma was confirmed histologically.

primary or secondary. Primary pulmonary lymphoma arises from bronchial mucosa-associated lymphoid tissue. The histologic appearance of primary pulmonary lymphoma therefore has a peribronchovascular distribution, though destruction of alveolar walls and dilation of airways are common, which accounts for the characteristic air bronchogram seen in humans with primary pulmonary lymphoma.³⁻⁵ In contrast, secondary pulmonary lymphoma may occur from direct extension of thoracic lymphadenopathy, via hematogenous or lymphatic spread, or

from foci of lymphoid tissue within the lung.³ The histologic appearance of secondary pulmonary lymphoma is highly variable, ranging from nodular interstitial thickening to interlobular septal thickening.³

In the present report, five cats and 13 dogs had secondary pulmonary lymphoma based on confirmation of lymphoma elsewhere in the body. Among the five remaining patients, two had concurrent hilar lymphadenopathy, one had mild medial iliac lymphadenopathy, and one was suspected to have gastrointestinal lymphoma; however,

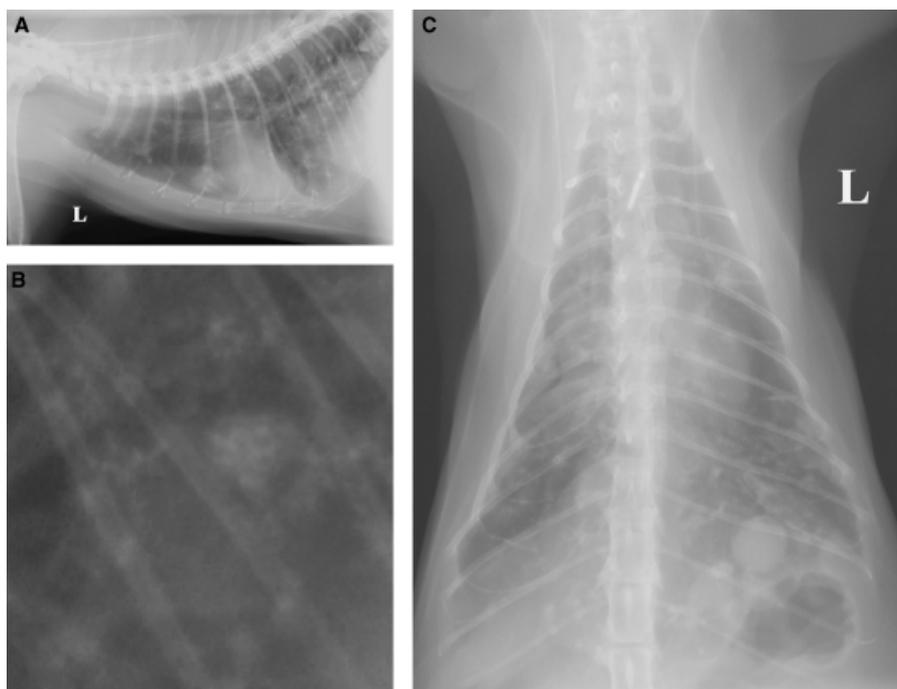


FIG. 5. (A) Left lateral thoracic radiograph of a 10 year-old Domestic Shorthair cat with multiple nodules and a moderate bronchial pattern with mineralization of the bronchial walls. (B) Close up image of the dorsocaudal lung highlighting mineralization of the bronchial walls. (C) Ventrodorsal thoracic radiograph of the same patient. Ultrasound-guided fine needle aspirates of the pulmonary nodules and kidneys were obtained and lymphoma was diagnosed in both organs.

samples were not obtained to confirm additional organ involvement. The fifth patient lacked a complete systemic evaluation to rule out extrathoracic lymphoma. Therefore, none of our patients met the criteria set in humans for the diagnosis of primary pulmonary lymphoma.

All of our patients had confirmed pulmonary lymphoma; however, pulmonary involvement is typically established in lymphoma patients when radiographic pulmonary changes are present, as other diagnostics are considered more invasive.^{1,2} Based on our results, pulmonary lymphoma has a highly variable radiographic appearance; thus, differentials for abnormal pulmonary infiltrates in cats and dogs with multicentric or extranodal lymphoma can include neoplastic infiltration, pulmonary fibrosis, bacterial pneumonia, feline asthma, chronic bronchitis, and cardiogenic pulmonary edema.¹⁹

Thoracic lymphadenopathy was seen radiographically in only five of 23 patients (22%). This is in contrast to other results where thoracic lymphadenopathy was detected radiographically in 64.4–72% of dogs with multicentric lymphoma.^{11,12} Pleural effusion was seen in three of 23 patients (13%), which is similar to previous reports.^{11,12} The atelectasis accompanying pleural effusion will complicate adequate pulmonary evaluation and probably contributed to the alveolar and interstitial infiltrates in these three patients. Additionally, pleural effusion can contain neoplastic cells and has the potential to result in contamination of

lung specimens that are obtained by needle aspiration. Lung specimens were obtained by surgical biopsy (one) or necropsy (two) in the three patients with concurrent pleural effusion; therefore, pulmonary lymphoma was definitively confirmed in all patients without contamination.

In our population, nodules and masses were considered as one category. Many of the radiographic images were reviewed as jpeg files; therefore, a reliable and consistent internal caliper for measuring nodules and masses was unavailable. Five lesions were classified as masses based on measurements >4 cm in diameter (two) and/or involvement of an entire lung lobe (four); the remainder of the nodules and masses could not be measured.

Five of our patients had a delay of greater than a week between thoracic radiographic examination and the diagnosis of pulmonary lymphoma. Despite this lag, most of these patients had severe radiographic pulmonary abnormalities including masses and alveolar patterns.

In conclusion, pulmonary lymphoma has a variable radiographic appearance and should be included as a differential when pulmonary infiltrates are detected on thoracic radiographs, especially in a patient that has previously been diagnosed with multicentric or extranodal lymphoma. Previously, pulmonary nodules and masses have been reported as rare in canine lymphoma patients,¹² however, our results suggest that pulmonary nodules and masses in the cat and dog with lymphoma are not uncommon.

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