SMALL ANIMALS/ EXOTIC

Thoracic radiographic findings for dogs with cardiac tamponade attributable to pericardial effusion

Etienne Côté, DVM, DACVIM; Leslie A. Schwarz, DVM, DACVR; Fortune Sithole, BVSc, PhD, DACVPM

Objective—To determine the prevalence of various radiographic findings for dogs with cardiac tamponade (CT) attributable to pericardial effusion (PE) and to determine the sensitivity and specificity of such findings for identification of affected dogs.

Design—Retrospective, randomized, blinded, controlled study.

Animals—50 dogs with CT attributable to PE and 23 control dogs (10 healthy dogs and 13 dogs with cardiac diseases other than CT).

Procedures—Thoracic radiographic images of dogs were evaluated by an observer who was unaware of the dogs' medical histories. For each dog, a vertebral heart score, globoid appearance of the cardiac silhouette, and convexity of the dorsocaudal aspect of the cardiac silhouette were determined.

Results—The sensitivity and specificity of enlargement of the cardiac silhouette (vertebral heart score, ≥ 10.7) for identification of dogs with CT attributable to PE were 77.6% and 47.8%, respectively. The sensitivity and specificity of a globoid appearance of the cardiac silhouette for identification dogs with CT were 41.9% and 40.0%, respectively. The sensitivity and specificity of a convex appearance of the dorsocaudal aspect of the cardiac silhouette for identification of dogs with CT were 57.1% and 35.0%, respectively.

Conclusions and Clinical Relevance—Results of this study indicated none of the evaluated radiographic variables was highly (> 90%) sensitive or specific for identification of dogs with CT attributable to PE. Thoracic radiographic findings should not be considered reliable for identification of dogs with CT attributable to PE. (*J Am Vet Med Assoc* 2013;243:232–235)

The characteristic radiographic sign of PE in dogs typically is defined as an enlarged cardiac silhouette with a globoid shape.[1,2] This radiographic finding is attributed to stretching of the pericardium via accumulation of PE fluid. However, the prevalence of such a radiographic finding for dogs with CT attributable to PE and the sensitivity and specificity of such findings for identification of dogs with that problem have not been reported. Pericardial effusion may not be identified in dogs with CT when the characteristic radiographic signs are not detected. Dogs for which PE is not suspected via radiography may not receive appropriate treatments, even when hemodynamically important PE (ie, PE that causes CT) is present and urgent intervention is required.

The objective of the study reported here was to determine the prevalence of various radiographic findings for dogs with CT attributable to PE and to determine the sensitivity and specificity of such findings for identification of affected dogs. The hypothesis was that > 90% of dogs with CT attributable to PE would have an enlarged cardiac silhouette with a globoid shape and convexity of the dorsocaudal aspect of the cardiac silhouette, as determined via evaluation of thoracic radiographic images.

Abbreviations

CI	Confidence interval
CT	Cardiac tamponade
PE	Pericardial effusion
VHS	Vertebral heart score

Materials and Methods

Animals—Medical records of dogs admitted to the Angell Memorial Animal Hospital from 1995 through 2003, the Veterinary Emergency and Specialty Center of New England from 2001 through 2002, and the Atlantic Veterinary College, University of Prince Edward Island, from 1988 through 2003 were reviewed to identify dogs with CT attributable to PE. Dogs with available thoracic radiographic images (≥ 1 lateral projection and a dorsoventral or ventrodorsal projection [with date and time markings confirming that the images had been obtained within 48 hours after hospital admission but before performance of pericardiocentesis]); echocardiographic evi-

From the Angell Memorial Animal Hospital, 350 S Huntington Ave, Boston, MA 02130 (Côté, Schwarz); the Department of Companion Animals, Atlantic Veterinary College, University of Prince Edward Island, Charlottetown, PE, C1A 4P3, Canada (Côté); and the Department of Paraclinical Sciences, Faculty of Veterinary Science, University of Pretoria, Private Bag X04, Onderstepoort 0110, South Africa (Sithole). Dr. Côté's present address is Department of Companion Animals, Atlantic Veterinary College, University of Prince Edward Island, Charlottetown, PE, C1A 4P3, Canada. Dr. Schwarz's present address is Veterinary Emergency and Specialty Center of New England, 180 Bear Hill Rd, Waltham, MA 02451.

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Address correspondence to Dr. Côté (ecote@upei.ca).

dence of PE, right atrial diastolic collapse with or without right ventricular diastolic collapse, and without clinically important primary valvular or myocardial disease (as determined by a board-certified cardiologist [EC]); and ≥ 2 select physical examination findings (tachycardia, abdominal distension consistent with ascites, weak pulse strength, and muffled heart sounds) were included in the study. Fifty dogs met these criteria and were included in the study.

Medical records were reviewed to identify control dogs with available thoracic radiographic images. An investigator (EC) who reviewed the medical records of dogs admitted to those same hospitals during those same time periods selected control dogs that were of similar age and somatotype as dogs with CT. Control dogs were identified in a randomized manner as determined by the random number function in a spreadsheet program by use of a ratio of case to control dogs established a priori as 3:1.[a] Two types of control dogs were included: healthy dogs with unremarkable thoracic radiographic findings as determined by board-certified radiologists at the time of examination (n = 10 dogs) and dogs with primary heart disease that did not have echocardiographic signs of CT (13).

Assessment of radiographic images—A board-certified radiologist (LAS) reviewed thoracic radiographic images of dogs with CT and control dogs. The radiologist was unaware of the groups in which dogs were included (CT vs control), the numbers of dogs in each group, and the signalments of the dogs. The radiologist determined a VHS[3] from the lateral radiographic projection of each dog as a measure of the size of the cardiac silhouette; on the basis of a clinically normal VHS range of 9.2 to 10.2 vertebral bodies (sum of the long and short axes of the heart),[3] a VHS ≥ 10.7 vertebral bodies was considered to indicate an enlarged cardiac silhouette and a VHS < 10.7 vertebral bodies was considered to indicate a cardiac silhouette that was clinically normal. The cardiac silhouette was evaluated to detect globoid shape and convexity of the dorsocaudal aspect in lateral thoracic radiographic images. Globoid appearance was defined as a generalized rounding of the cardiac silhouette in 1 or more radiographic projections with loss of the normal appearance of the cranial and caudal aspects (ie, waists; **Figure 1**). Convexity of the dorsocaudal aspect of the cardiac silhouette was defined as focal rounding of the caudal cardiac waist immediately ventral to the caudal pulmonary vessels. The observer assessing the radiographic images identified globoid appearance and convexity of the dorsocaudal aspect of the cardiac silhouette as present, absent, or equivocal (when the presence or absence of those characteristics could not be determined with confidence via evaluation of the radiographic images).

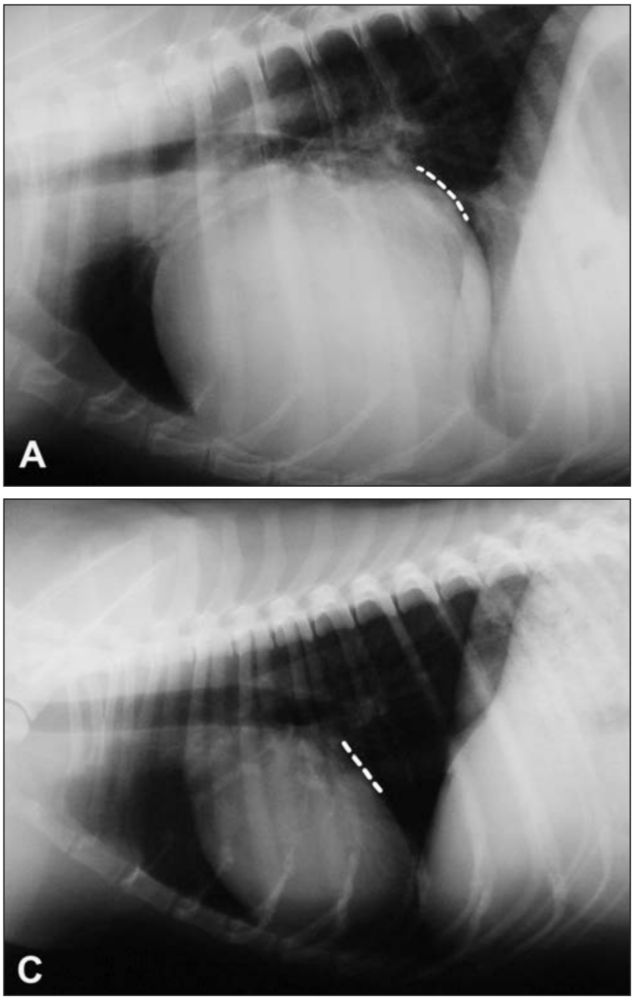
Statistical analysis—Sensitivity and specificity of a VHS ≥ 10.7 vertebral bodies, detection of a globoid appearance of the cardiac silhouette, and detection of convexity of the dorsocaudal aspect of the cardiac silhouette for identification of dogs with CT were determined with a χ^2 test by use of software.[b] The VHSs for control dogs and dogs with CT were compared via a 2-sample Kolmogorov-Smirnov test.[b] Values of $P \leq 0.05$ were considered significant.

Results

Fifty dogs with CT and 23 control dogs were included in the study. Of the control dogs, 10 were clinically normal, 7 had dilated cardiomyopathy, 4 had myxomatous mitral valve disease, and 2 had cor pulmonale. Information regarding age, breed, and sex was available for 49 of the 50 dogs with CT and for all 23 control dogs. The mean ± SD age of dogs with CT was 8.9 ± 3.2 years (median, 9 years; range, 1 to 15 years); 25 of these dogs were spayed females, 2 were sexually intact females, 19 were castrated males, and 3 were sexually intact males. Breeds of dogs with CT included Golden Retriever (n = 14), purebred or crossbred German Shepherd Dog (7), purebred or crossbred Labrador Retriever (6), Weimaraner (2), purebred or crossbred Beagle (2), Greyhound (2), purebred or crossbred Rottweiler (2), indeterminate breed (2), and 1 dog of each of 12 other breeds. The mean ± SD age of control dogs was 9.9 ± 2.2 years (median, 10 years; range, 6 to 13 years); 13 of these dogs were spayed females, 8 were castrated males, and 2 were sexually intact males. Breeds of control dogs included Golden Retriever (n = 4), purebred or crossbred German Shepherd Dog (4), purebred or crossbred Labrador Retriever (4), and 1 dog of each of 11 other breeds.

Thirty-nine of the 50 (78%) dogs with CT had a VHS ≥ 10.7 vertebral bodies, and 12 of the 23 (52%) control dogs had a VHS ≥ 10.7 vertebral bodies; these data were significantly ($P = 0.03$) different. Dogs with CT had a slightly larger cardiac silhouette (mean ± SD VHS, 11.9 ± 1.3 vertebral bodies; median VHS, 11.8 vertebral bodies) versus that of control dogs (mean ± SD VHS, 11.4 ± 1.5 vertebral bodies; median VHS, 10.8 vertebral bodies), but this difference was not significant ($P = 0.18$) and was not considered clinically important. A globoid appearance of the cardiac silhouette was detected for 25 of 43 (58%) dogs with CT and 8 of 20 (40%) control dogs (radiographic image analysis results for this variable were equivocal for 7 dogs with CT and 3 control dogs, and data for these dogs were excluded from analysis); these results were not significantly ($P = 0.18$) different. Convexity of the dorsocaudal aspect of the cardiac silhouette in lateral thoracic radiographic images was detected for 28 of 49 (57%) dogs with CT and 13 of 20 (65%) control dogs (this variable could not be reliably determined for 1 dog with CT and 3 control dogs, and data for these dogs were excluded from analysis); these results were not significantly ($P = 0.55$) different.

The sensitivity and specificity of a VHS ≥ 10.7 vertebral bodies for identification of dogs with CT were 77.6% (95% CI, 63.4% to 88.2%) and 47.8% (95% CI, 26.8% to 69.4%), respectively. The sensitivity and specificity of detection of a globoid appearance of the cardiac silhouette for identification of dogs with CT were 41.9% (95% CI, 27.0% to 57.9%) and 40.0% (95% CI, 19.1% to 63.9%), respectively. The sensitivity and specificity of detection of convexity of the dorsocaudal aspect of the cardiac silhouette in lateral thoracic radiographic images for identification of dogs with CT were



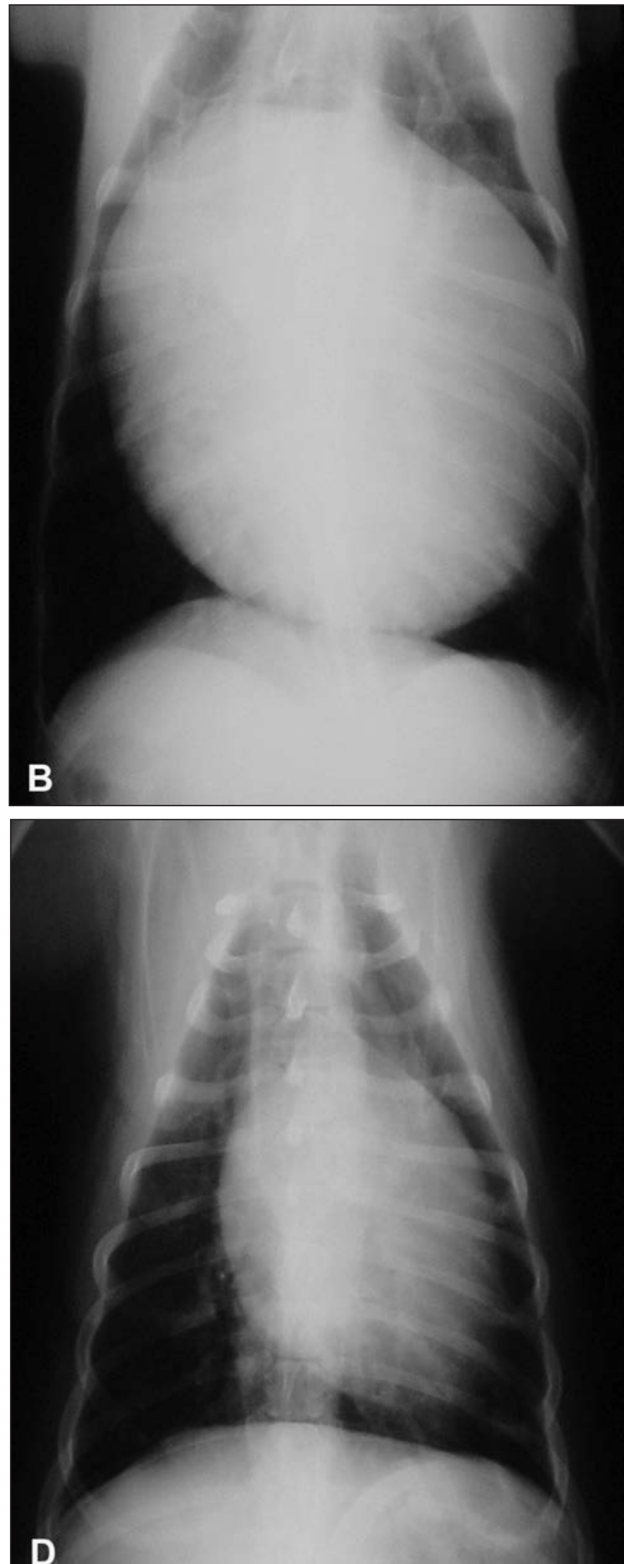


Figure 1—Lateral (A and C) and dorsoventral (B and D) thoracic radiographic images of a dog with CT and radiographic findings consistent with PE (A and B) and a dog with CT and unremarkable radiographic findings (C and D). In panels A and B, notice that the cardiac silhouette is enlarged (VHS, 13 vertebral bodies) and has a globoid appearance. In panel A, notice the convex appearance of the dorsocaudal aspect of the cardiac silhouette (broken line). In panels C and D, notice the clinically normal size (VHS, 10 vertebral bodies) and shape of the cardiac silhouette. In panel C, notice the clinically normal appearance of the shape of the dorsocaudal aspect of the cardiac silhouette (broken line). Results of the present study differed from those of prior studies regarding the radiographic appearance of hearts of dogs with CT attributable to PE; on the basis of results of prior studies, the radiographic findings for images in panels C and D would have been considered atypical for dogs with PE, and CT may have been erroneously ruled out for such dogs.

57.1% (95% CI, 42.2% to 71.2%) and 35.0% (95% CI, 15.4% to 59.2%), respectively.

Results of analysis of multiple variables revealed that the combination of a VHS ≥ 10.7 vertebral bodies and detection of a globoid appearance of the cardiac silhouette in the same lateral thoracic radiographic image had a sensitivity of 31% and a specificity of 66.7% for identification of dogs with CT. The combination of a VHS ≥ 10.7 vertebral bodies and detection of convexity of the dorsocaudal aspect of the cardiac silhouette in the same lateral thoracic radiographic image had a sensitivity of 47.6% and a specificity of 61.1% for identification of dogs with CT. Detection of both a globoid appearance of the cardiac silhouette and convexity of the dorsocaudal aspect of the cardiac silhouette in the same lateral thoracic radiographic image had a sensitivity of 39.5% and a specificity of 38.9% for identification of dogs with CT. The combination of a VHS ≥ 10.7 vertebral bodies, detection of a globoid appearance of the cardiac silhouette, and detection of convexity of the dorsocaudal aspect of the cardiac silhouette in the same lateral thoracic radiographic image had a sensitivity of 31% and a specificity of 66.7% for identification of dogs with CT.

Discussion

Results of this study indicated that none of the evaluated radiographic variables had a high (ie, > 90%) sensitivity for identification of dogs with CT. Dogs in the study had signs of hemodynamic compromise at the time radiographs were obtained; 22% of such dogs with PE did not have an enlarged cardiac silhouette, 42% of such dogs did not have a globoid appearance of the cardiac silhouette, and 43% of such dogs did not have detectable convexity of the dorsocaudal aspect of the cardiac silhouette in lateral thoracic radiographic images.

The specificity of the evaluated variables for identification of dogs with CT was poor. Although a higher percentage of dogs with CT (78%) than control dogs (52%) had an enlarged cardiac silhouette in lateral thoracic radiographic images, that difference in percentages between groups was small, and similar VHS values were determined for dogs with CT (mean ± SD VHS, 11.9 ± 1.3 vertebral bodies) and control dogs (mean ± SD VHS, 11.4 ± 1.5 vertebral bodies). Similarly, qualitative assessments of cardiac silhouette appearance (detection of globoid appearance and convexity of the dorsocaudal aspect) had low specificity for differentiation between dogs with CT and control dogs. Similar percentages of dogs with CT and control dogs had a globoid appearance (58% and 40%, respectively) and convexity (57% and 65%, respectively) of the cardiac silhouette. Even when all 3 evaluated abnormalities were detected in the same lateral thoracic radiographic image, specificity for identification of dogs with CT was only 66.7%. On the basis of the results of this study, radiographic characteristics cannot reliably be used for differentiation between dogs with CT and those without that problem.

The shape and size of the pericardial sac can be affected by various factors, including the net rate of accumulation of PE fluid and distensibility of the pericardium. Acute PE is less likely to induce stretching of the pericardium than is chronic PE in humans[4]; this may also be true for dogs with CT.[5] The capacity of normal pericardial tissue to stretch varies among dogs.[6] Therefore, changes in size of the cardiac silhouette may vary among dogs with equivalent volumes of PE fluid. In addition, pericardial diseases may be associated with a decrease in pericardial compliance for dogs with (effusive-constrictive pericardial disease) or without (constrictive pericarditis) PE.[7] For these reasons, acute or chronic severe PE may or may not cause thoracic radiographic changes in dogs. The wide range of values for evaluated variables in this study may have been attributable to these factors.

Other authors[1,2] have described radiographic findings for dogs with PE without commenting on the hemodynamic effects of the PE. Dogs in the present study had CT, whereas the presence or absence of CT in dogs was not indicated in previous reports.[1,2] Although PE may develop as a result of systemic disorders (eg, uremia or coagulopathy) or intrapericardial disorders (eg, inflammation or neoplasia),[4] such disorders cause a wide range of hemodynamic effects.[4] In the dogs evaluated in this study, PE may not have been present for a sufficiently long period to allow development of pericardial stretching[5] or the pericardium may have been inherently inelastic.[6] The belief that dogs with CT typically have an enlarged, globoid cardiac silhouette in thoracic radiographic images may be attributable to the fact that dogs with CT and those with any type of PE have not been evaluated separately in other studies.

Advantages of this study were the inclusion of dogs with confirmed CT that underwent radiography prior to performance of pericardiocentesis, randomized selection of control dogs (healthy dogs and dogs with heart disease not attributable to CT), and blinding of the observer to the status (case vs control) of dogs. This study had several limitations that could be investigated during future studies: we did not compare the diagnostic value of radiography versus physical examination for dogs with CT,[7] determine the repeatability of qualitative and quantitative data for radiographic image variables by a single observer or multiple observers, use breed-specific reference intervals for VHS values, or assess additional radiographic variables including caudal vena cava size[8] and cardiac silhouette sphericity.[2]

a. Excel, Microsoft Corp, Redmond, Wash.
b. Stata, version 10, StataCorp, College Station, Tex.

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