THE EFFECT OF POSITIONING ON THE RADIOGRAPHIC APPEARANCE OF CAUDODORSAL MEDIASTINAL MASSES IN THE DOG

ROBERT M. KIRBERGER, ERAN DVIR, LIESEL L. VAN DER MERWE

In this prospective study, the effect of thoracic positioning on the visibility and size of caudal esophageal masses caused by spirocercosis was investigated. Dorsoventral (DV), ventrodorsal (VD) as well as left lateral recumbent (LLR) and right lateral recumbent (RLR) thoracic radiographs of 28 dogs, diagnosed endoscopically with spirocercosis, were evaluated. The radiographic findings were compared with those of esophageal endoscopy. Masses were seen equally well in left vs. right recumbency as well as in DV vs. VD positions but in DV/VD views 86% of masses were detected whereas in lateral views only 50% of masses were identified. In spirocercosis-endemic areas DV and RLR views are advised as they also allow for better visualization of descending aorta aneurysms and to avoid interpreting the potentially normally visible esophagus in LLR in large dogs as a mass.
Veterinary Radiology & Ultrasound, Vol. 50, No. 6, 2009, pp 630–634.

Key words: dog, esophagus, mediastinum, positioning, radiology, spirocercosis, *Spirocerca lupi*, thorax.

Introduction

ROUTINE RADIOGRAPHIC EXAMINATION of the thorax consists of a lateral view, left (LLR) or right lateral recumbent (RLR) and its orthogonal dorsoventral (DV) or ventrodorsal (VD) counterpart. In order to select the most informative views, the investigator must understand the effect positioning has on the radiographic appearance of the normal thorax as well as that of thoracic disease. The effect of various radiographic views on the visibility or position of normal thoracic structures has been described.[1,2] Various views have also been used to better define thoracic disease.[3–5] Mediastinal lesions are generally better delineated on a DV or VD.[3,6,7] However, standard texts do not discuss the effect of positioning on the caudodorsal mediastinum or ignore caudodorsal mediastinal masses completely,[6] with only some texts commenting that a VD is better for caudoventral mediastinal disease[3,6] or that a VD is better for mediastinal disease in general.[3,8]

Anatomic structures in the caudodorsal mediastinum are the dorsal intercostal arteries and veins, esophagus, thoracic duct, right and left sympathetic trunks and vagal nerves, descending aorta, bronchoesophageal arteries and veins, and the azygos vein.[6] In normal dogs the esophagus is not visible except occasionally in large breed dogs just cranial to the diaphragm in LLR radiographs.[2] The descending mid-mediastinal aorta is seen reasonably well at the level of the heart and is seen better on DV and LLR radiographs,[2] however, the caudal mediastinal aorta becomes less well defined on the lateral view as well as on the DV/VD views as its left edge joins the vertebral column border. The remaining caudodorsal mediastinal structures are not visible in the normal dog.

Caudodorsal mediastinal disease, and in particular that causing a mass effect, primarily involves the esophagus. Abnormalities include foreign body, in endemic areas *Spirocerca lupi* nodules and neoplastic transformation thereof, food or fluid filled megaesophagus, hiatal hernia, gastroesophageal intussusception, primary and metastatic neoplasia, and esophageal diverticula.[6,8–11] Caudodorsal mediastinal mass effect may also be due to paraesophageal hernia, diaphragmatic rupture, hernia, abscess or hematoma, neoplasia of neural or vertebral body origin, migrating foreign bodies, and mediastinitis secondary to esophageal perforation.[6,8,10,11] Vascular causes of a caudodorsal mediastinal mass include aortic aneurysms, usually secondary to *S. lupi* larval migration and markedly distended azygos vein secondary to absent prehepatic caudal vena cava or a portoazygous shunt.[10,12]

This prospective study was undertaken to determine the effect of positioning on the visibility and size of the caudodorsal mediastinum, and particularly in dogs with endoscopically confirmed intraluminal *S. lupi* nodules in the caudal esophagus.

Materials and Methods

We selected 28 dogs from a larger prospective spirocercosis trial in which caudal esophageal nodules were diagnosed by means of endoscopy within 5 days of the radiographic examination. Dogs had a mean age of 52.5 ± 29.6 months (range 9–125) and weight of 19.4 ± 12.4 kg (range 3.6–41.5). Breeds were six Jack Russell Terriers, three German

From the Department of Companion Animal Clinical Studies, Faculty of Veterinary Science, University of Pretoria, Private Bag X04, Onderstepoort 0110, Pretoria, South Africa.

Address correspondence and reprint requests to Robert M. Kirberger, at the above address. E-mail: robert.kirberger@up.ac.za

Received April 4, 2009; accepted for publication May 11, 2009.
doi: 10.1111/j.1740-8261.2009.01594.x

Shepherd dogs, three Boerboels, three Bull Terriers, and the remaining 13 were mixed or single representatives of a purebreed. All dogs were evaluated over a 1-year period (2007/2008). Each dog had four standard radiographic thoracic views made (DV, VD, RLR, and LLR). All images were digital radiographs retrieved from the Onderstepoort Veterinary Academic Hospital picture archiving system. All radiographs were evaluated by a single board certified radiologist (R.M.K.) and contrast, brightness, and magnification adjusted to optimize pathology. All four views were examined independently from each other to avoid interpretation bias due to known mass on another view.

On each of the four views the visibility of a mass was evaluated as definitely not present, possibly present, likely to be present, and definitely present. Additionally, the length and height of the mass was measured in millimeters on lateral views and the length and width on DV and VD views.

Confirmation of a suspect caudodorsal mediastinal mass was made in all patients by means of esophageal and gastric endoscopy.* Patients were premedicated with a variety of drugs depending on clinician preference, but all were induced with propofol† and maintained on isoflurane‡. The dogs were in LLR and esophageal and gastric endoscopy, particularly of the cardia, was performed. The *S. lupi*-associated nodules were assessed according to number, characteristics (smooth or cauliflower like) and individual length as well as confluent length of esophageal involvement. The length of each nodule was determined by measuring its distance from the canine tooth and subtracting the most caudal measurement from the more cranial. Where several nodules were present the total length of esophagus involved was taken to be the distance from the cranial edge of the first nodule to the caudal edge of the last nodule or cardia, if the nodule involved the cardia. This was then compared with the radiographs where only one mass was visible. The diameter of the nodules could not be ascertained endoscopically.

Data were captured and analyzed statistically in Excel software. Results were expressed as mean ± standard deviation and range. Visibility of the masses between the four views was compared using the χ^2-test. To measure the sensitivity of each view for mass detection, definitely not present and possibly present were combined and classified as not detected, and likely to be present and definitely present were combined and classified as detected. Length measurements on the different views were tested for a linear association with endoscopic measurements. The difference in the nodule mean length was compared between the better lateral view, based on the above mentioned analyses, and the better VD/DV view using paired Student's *t*-test. The significance level for all tests was $P<0.05$.

*Olympus GIF video endoscope, type XQ200, Tokyo, Japan.
†Fresenius Kabi Pty Ltd., Halfway House, South Africa.
‡Safeline pharmaceuticals Pty Ltd., Florida, South Africa.

TABLE 1. Total Length of Esophageal Involvement in Endoscopically Seen Nodules and Radiographically Identified Masses

View	Range (mm)	Mean ± SD
RLR	19–118	56.29 ± 30.93
LLR	23–135	54.44 ± 29.94
DV	20–145	66.25 ± 37.36
VD	24–151	67.79 ± 30.21
Mean of four views	26–137.2	58.45 ± 28.41
Endoscopy	10–150	62.22 ± 43.18

RLR, right lateral recumbent; LLR, left lateral recumbent; DV, dorsoventral; VD, ventrodorsal thoracic views.

Results

One to nine nodules (mean 2.4, median 1) were identified endoscopically per dog and 14 dogs had more than one nodule. The total length of esophageal involvement in endoscopically seen nodules and radiologically identified masses are given in Table 1.

Masses were seen equally well in left vs. right recumbency as well as in DV vs. VD positions (Table 2). However, in the latter 24/28 (86%) masses were identified, whereas in lateral views only 14/28 (50%) masses were identified and this difference was statistically significant ($P<0.01$) (Fig. 1). In 10 dogs masses were seen only on DV and VD radiographs. While DV or VD views were superior for detection, the right lateral recumbent view was superior for measurement, being characterized by the strongest association with endoscopic measurement ($r^2=0.83$ (Fig. 2) compared with $r^2=0.44$ for the DV). The mean length measurements of the lateral view having the best correlation to endoscopy, namely RLR, and the best view in terms of detectability, namely DV, were compared and were significantly different ($P<0.001$) with shorter length measured on lateral recumbency compared with DV. There was no significant difference between the endoscopic measurement and lateral recumbent view measurement. Endoscopic details, such as proliferation and necrotic craters could not be detected radiologically.

Height and width of masses could not be compared with endoscopic data as these measurements cannot readily be made endoscopically. The correlation between the average of mean DV and VD width was 1.15 times bigger (data not

TABLE 2. Visibility of Masses on Different Views

	Not Visible		Visible	
View	Definite No	Possibly	Likely	Definite Yes
RLR	8	6	6	8
LLR	4	10	4	10
DV	2	2	5	19
VD	4	0	7	17

RLR, right lateral recumbent; LLR, left lateral recumbent; DV, dorsoventral; VD, ventrodorsal thoracic views.

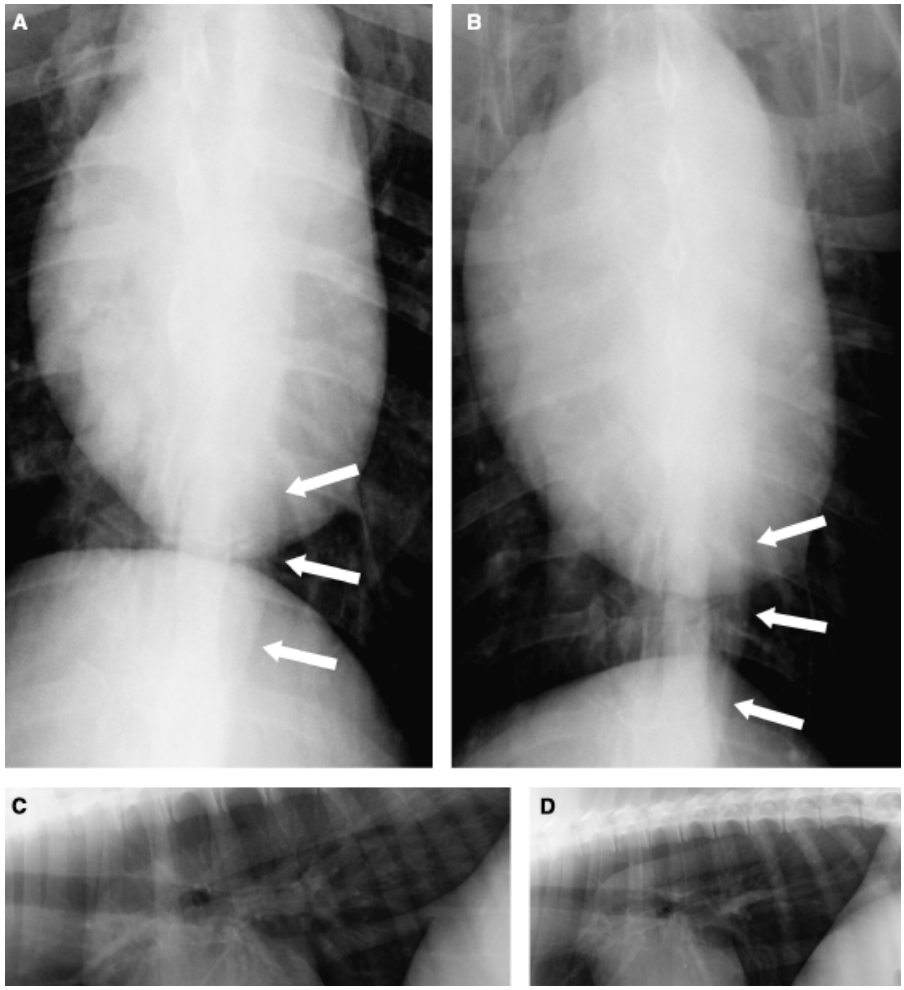

FIG. 1. Mid caudal and caudodorsal thoracic radiographs of a 6-year-old Great Dane with spirocercosis. (A) Dorsoventral view with obvious lesion superimposed on caudal cardiac and diaphragmatic silhouettes. (B) Ventrodorsal view with similar lesion. (C) Right lateral recumbent and (D) left lateral recumbent views with no caudodorsal mediastinal mass visible.

shown) compared with the average of the mean RLR and LLR heights, indicating the *S. lupi*-induced masses had a discoid shape radiographically.

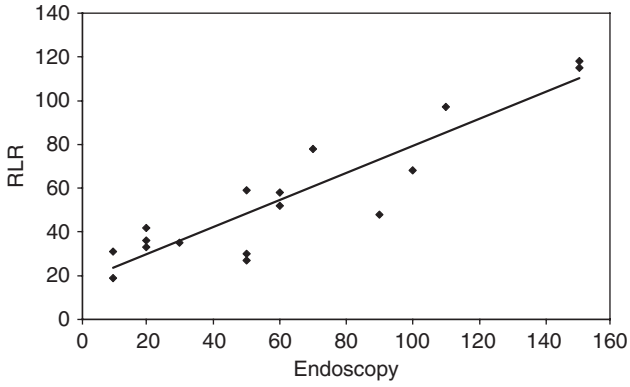

FIG. 2. Radiographic measurement (mm) in right lateral view as a function of endoscopic measurement (mm). The line is the best fitting linear regression line. $R^2 = 0.83$.

The smaller radiologically detected masses consistently measured slightly larger on the radiographic vs. the endoscopic measurements, whereas the larger radiographic masses were smaller than the endoscopic measurements (Fig. 3).

Discussion

When radiographing the canine thorax, it is essential for the clinician to be aware of the effect that a radiographic projection can have on the radiographic conspicuity and location of normal thoracic structures as well as abnormalities.

The effect of positioning on a variety of thoracic lesions has been described[3–5] but to date the accuracy of various views to diagnose caudodorsal mediastinal disease, and in particular esophageal disease, has not been described.

Subtle or early disease of the mediastinum is often difficult to assess and a thorough knowledge of the factors that influence its size and visibility are imperative.

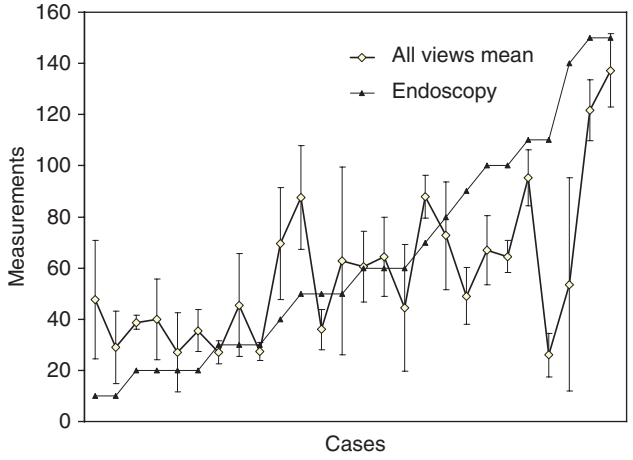

FIG. 3. Mean nodule size in mm (scale bar = SD) as seen on radiographs compared with endoscopic size. Note that smaller nodules are larger radiographically than endoscopically and vice versa for larger nodules.

Based on our results, DV/VD radiographs are more reliable for detection of a caudodorsal mediastinal mass than are lateral radiographs. There were no significant differences in the visibility indices between VD and DV. As there is no significant difference in mass detectability between VD and DV views, other factors should be taken into consideration when deciding which view to make. In spirocercosis-endemic areas the left lateral border of the descending aorta is evaluated for evidence of aneurysms and as the aorta is better defined on the DV view, this view should take preference.[10,13]

Although not proven to have a beneficial effect in this study, factors that should result in improved visibility should be considered. On the DV view the surrounding lung is more air filled, which should result in greater contrast between it and the soft tissue opacity of the esophagus as well as having slight magnification of the dorsal mediastinal structures.[3,14] Making a choice between RLR and LLR is also possible. Although the aorta is seen better on an LLR view spirocercosis aneurysms are rarely seen on lateral views. A normal esophagus may be seen in large breed dogs in LLR radiographs[2] and this could be confused with disease and a RLR should thus be made to avoid this pitfall. The RLR view also resulted in the most accurate quantification of the dimensions of the mass. Under no circumstances should only lateral views be made as lesions may be missed. There were two dogs with 10 mm nodules, one of which was seen on two views and the other on three views, whereas one dog had a 20 mm nodule that was not seen on any view. Many nodules were seen on all views but some nodules endoscopically <150 mm long were only seen on some views. The two dogs with the largest nodules of 150 mm were seen on all views. The above emphasizes the fact that a negative radiographic study does not necessarily rule out a caudal esophageal mass or foreign body and if clinical signs persist, endoscopy, a contrast study or computed tomography (CT) examination with the esophagus inflated[13] should be performed.

The fact that smaller masses detected radiographically were larger than that measured endoscopically (Fig. 3) can be explained by the fact that the esophagus will taper on either side of the mass to a normal empty diameter resulting in increased length. Larger endoscopic nodules were seen as smaller masses radiographically, which is likely due to the fact that the larger nodules measured on endoscopy were often the result of several nodules added together to give the total length of the mass. In these instances of multiple nodules, some nodules were very small and could have been on the extremities of the length measured and would not have distended the esophagus sufficiently to create a radiographic mass effect.

Possible limitations were that all dogs were known to be positive and specificity and predictive values of various views compared with known normal dogs could not be determined. However, the objective was to determine which views were most appropriate to detect masses in dogs with known disease and it can be concluded that RLR and DV views should be made to evaluate caudodorsal mediastinal abnormalities, particularly in spirocercosis endemic areas. Using endoscopy as the standard for mass detection is also not ideal. Endoscopy is good for nodule detection,[10] but only detects the intraluminal esophageal part of the nodule and therefore, the measurement might not be that accurate. CT is a better three-dimensional tool to assess nodule size and future radiographic studies should be compared with CT as the gold standard.

REFERENCES

1. Kirberger RM, Avner A. The effect of positioning on the appearance of selected cranial thoracic structures in the dog. Vet Radiol Ultrasound 2006;47:61–68.

2. Avner A, Kirberger RM. Effect of various thoracic radiographic projections on the appearance of selected thoracic viscera. J Small Anim Pract 2005;46:491–498.

3. Brinkman EL, Biller D, Armbrust L. The clinical usefulness of the ventrodorsal versus dorsoventral thoracic radiograph in the dog. J Am Anim Hosp Assoc 2006;42:440–449.

4. Thrall DE. The pleural space. In: Thrall DE (ed): Textbook of veterinary diagnostic radiology, 5th ed. Philadelphia: WB Saunders, 2007; 555–567.

5. Lang JW, Wortman JA, Glickman LT, Biery DN, Rhodes H. Sensitivity of radiographic detection of lung metastases in the dog. Vet Radiol 1986;27:74–78.

6. Thrall DE. The mediastinum. In: Thrall DE (ed): Textbook of veterinary diagnostic radiology, 5th ed. Philadelphia: WB Saunders, 2007; 541–554.

7. Baines E. The mediastinum. In: Schwarz T, Johnson V (eds): BSAVA manual of canine and feline thoracic imaging. Quedgeley: BSAVA, 2008;177–199.

8. Watrous BJ. Esophagus. In: Thrall DE (ed): Textbook of veterinary diagnostic radiology, 5th ed. Philadelphia: WB Saunders, 2007;495–509.

9. Ridgway R, Suter P. Clinical and radiographic signs in primary and metastatic esophageal neoplasms of the dog. J Am Vet Med Assoc 1974;174: 700–774.

10. Dvir E, Kirberger RM, Malleczek D. Radiographic and computed tomographic changes and clinical presentation of spirocercosis in the dog. Vet Radiol Ultrasound 2001;42:119–129.

11. Dennis R, Kirberger RM, Wrigley RH, Barr FJ. Small animal radiological differential diagnosis. London: WB Saunders, 2001;143–153.

12. Fischetti AJ, Kovak J. Imaging diagnosis: azygous continuation of the caudal vena cava with and without portocaval shunting. Vet Radiol Ultrasound 2008;49:573–576.

13. van der Merwe LL, Kirberger RM, Clift S, Williams M, Keller N, Naidoo V. *Spirocerca lupi* infection in the dog: a review. Vet J 2008;176: 294–309.

14. Berry CR, Graham JP, Thrall DE. Interpretation paradigms for the small animal thorax. In: Thrall DE (ed): Textbook of veterinary diagnostic radiology, 5th ed. Philadelphia: WB Saunders, 2007;462–485.