Computed Tomographic Features of Spirocercosis with Putative Benign Oesophageal Nodules in Dogs

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ABSTRACT

The objective of this study was to describe and characterize the computerized tomography (CT) findings of *Spirocerca lupi* esophageal putative benign nodules and to describe CT features of spirocercosis. For this purpose medical records and CT images of eleven dogs with confirmed spirocercosis for which histology was performed were examined retrospectively. The predominant oesophageal lesions were located in the caudal thoracic oesophagus. The oesophageal nodules were located in the dorsal esophageal wall in 9 of the 11 cases. Most lesions were singular (8/11), round to oval, clearly demarcated, ranging from 2.5 to 7 cm in diameter with irregular hypoattenuating eccentric centres surrounded by isoattenuating smoothly demarcated walls. In the contrast-enhanced scans, the nodular wall was moderately opacified due to contrast uptake in ten of the cases. None of the nodules was mineralized. Six of the dogs had calcifications of the aortic wall, three of which had aneurismal dilation at the caudal thoracic aorta. Two dogs had mediastinal and pleural haemorrhagic effusions due to a narrow rupture of the aortic wall. One dog had a large intraluminal aortic thrombus in the caudal abdomen associated with focal aneurismal dilatation of the aortic wall. Two dogs had aneurismal dilatation of the coeliac artery near the origin of the vessel. This study demonstrated the benefits and sensitivity of CT studies in the investigation of canine spirocercosis. CT proved to be extremely sensitive for the investigation of vascular lesions such as arterial aneurysms, rupture and thromboembolisms. It appears that *S. lupi* esophageal nodules that have not gone neoplastic transformation typically have eccentric or central hypoattenuating areas surrounded by soft tissue walls showing moderate to distinct contrast uptake and were not mineralized.

Key Words: *Spirocerca lupi*, Computed Tomography, oesophagus, aortic aneurysm, thrombus

INTRODUCTION

Spirocerca lupi, the dog oesophageal worm, is a nematode distributed mainly in tropical and subtropical regions (1). Dogs become infested following ingestion of the intermediate host, a corpophageous beetle, or a paratenic host. After ingestion, *S. lupi* third stage (L3) larvae are liberated in the gastric lumen, migrate through the stomach wall, via the gastroepiploic arteries, to the coeliac artery and cranially to the abdominal aorta and to the caudal thoracic aorta. Larvae spend up to three months in small nodules in the aortic wall, where they molt to fourth stage (L4) larvae and finally to young adults (L5). From there the young adults migrate to the caudal oesophagus. Groups of three to six worms cluster in the oesophageal submucosa and induce the formation of a nodule (1). Most lesions produced by *S. lupi* are caused by migration and persistence of the larvae and adult worms. Thoracic radiography (survey and contrast oesophagography), corposcopy and oesophgoscopy are commonly used in the diagnosis of *S. lupi* infestation, but some infections may

be missed. Oesophageal nodules may transform into sarcomas (fibrosarcomas, chondrosarcomas, osteosarcomas and undifferentiated sarcomas). Aortic aneurysms, mineralization and thrombosis, thoracic spondylitis and discospondylitis, hypertrophic osteopathy (HO), sialoadenosis and pyothorax were also been documented (2-9). Aberrant migration may result in variable clinical conditions, but the most common presentations include respiratory, neurological and musculoskeletal signs (10-12).

Malignant oesophageal neoplasms may metastasize to other sites, mostly to the lungs (1, 13-16). Although oesophageal neoplastic masses tend to be larger, mineralized, pedunculated or cauliflower-like and are more likely to be associated with HO and spondylitis (16), there are no reliable radiological parameters to differentiate malignant from benign lesions. Although, the endoscopic appearance of the oesophageal lesions often differentiate benign from malignant lesions, in some cases, differentiation is challenging or impossible (17). Furthermore, endoscopic biopsies may be misleading because they are mostly superficial, revealing inflammation rather than the deep-seated neoplastic process (10, 17).

It was suggested that computed tomography (CT) might assist in determining the exact morphology of the oesophageal lesions, particularly the presence of early mass mineralization, which may suggest neoplastic transformation. CT might also be useful in identifying lesions in the surrounding structures and in detecting early pulmonary metastases (10). The purpose of this report is to describe and characterize the CT findings of non-neoplastic *S. lupi*-associated oesophageal nodules.

MATERIAL AND METHODS

The medical records and CT images of dogs with histologically confirmed spirocercosis between 2007 and 2010 were examined retrospectively.

All the dogs had endoscopic findings compatible with benign oesophageal nodules. In nine dogs the diagnosis of non-neoplastic oesophageal nodules was made by endoscopic biopsies and in two dogs the diagnosis was made by ultrasound-guided transhepatic tru-cut biopsies. All the procedures were performed at the time or within 3 days of the CT investigation. All the dogs were evaluated for hypertrophic osteopathy of all four distal limbs by survey radiographs.

In all dogs, CT images were acquired using a third generation (2 slice) helical CT scanner operating in helical mode (MxTwin Dual (2 slice) helical CT, Manufacturer Picker, Israel). Nine dogs were sedated using a combination of medetomidine (Domitor, Orion Corporation, Espoo, Finland) (10 μg/kg IV) and butorphanol (Torbugesic, Fort Dodge Animal Health, Fort Dodge, Iowa 50501 USA) (0.1mg/kg IV) and positioned in the prone position for scanning. The remaining two cases were anaesthetized (induction by propofol, 4mg/kg IV (Rapinovet,Merck Animal Health, Kirkland, Canada) and maintained by isoflurane (Isocare, Piramal Healthcare, Digwal, India)) and were positioned in dorsal recumbency with the forelimbs extended cranially for scanning. There was no attempt to control breathing in these studies. Image acquisition extended from the thoracic inlet to the level of the third lumbar vertebra. Thickness slices 2.7 millimeters were acquired at 2.5 millimeter increment. Images were reformatted with bone, soft tissue and lung filters. Window width (WW) and window level (WL) were standardized for evaluation; WW=2500 Hounsfield units (HU) and WL=480HU for images with bone filter, WW=350HU and WL=90HU for images with soft tissue filter and WW=1000HU and WL=-650HU for images with lung filter. Manual cephalic vein injection of a non-ionic iodinated contrast medium (Iohexol 300, 300mg I/ ml (Omnipaque, GE Healthcare, Cork, Ireland)) was performed using a dose of 600 mg iodine/kg. The delay between administration and image acquisition varied between 30 and 45 sec.

All images were reviewed by one of the authors (A-A). The following parameters were evaluated: oesophageal mass, location, size, shape, attenuation characteristics, and evidence of mineralization and contrast uptake characteristics. Other related findings were recorded: thoracic vertebral spondylitis, aortic lesions (mineralization, aneurysm formation and thromboembolism), HO, pulmonary, mediastinal and lymph node abnormalities.

An attenuation value for the inner hypoattenuating (to surrounding tissue and esophageal wall) cavity of the esophageal nodules was measured in HU before and after contrast medium administration using a region of interest (ROI) of $3mm^2$. The position of the ROI was identical in the pre- and postcontrast images. ROIs were positioned within the esophageal nodules in two different sequential slices and the readings averaged. Only the single most prominent nodule was investigated in this way in each dog.

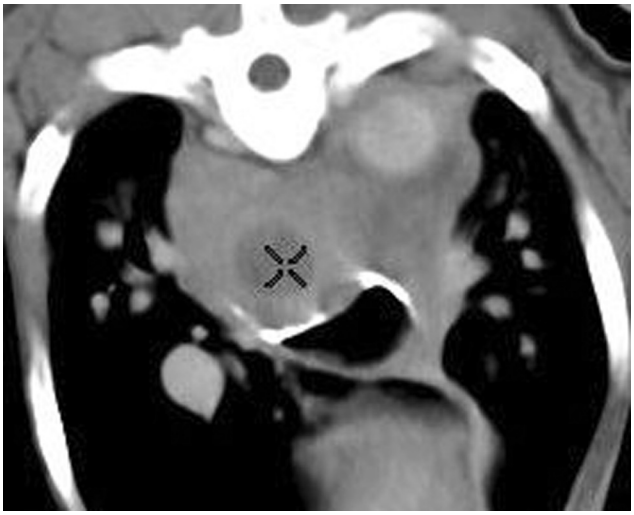


Figure 1: Typical *S. lupi* nodule: A. Transverse contrast-enhanced CT image zoomed on a caudal oesophageal wall of a five year old, female, German Shepherd Dog. Note a roughly spherical dorsal oesophageal wall mass showing rim enhancement with round central hypoattenuating region (X) due to tissue necrosis and collection of inflammatory fluid. The thoracic oesophagus was distended with air and small amount of contrast fluid (Iohexol). The contrast fluid delineates the oesophageal wall mucosal surface showing a filling defect which correlated with an opening into the nodule. Note the mild aortic distension and tick irregular wall. At that level the mediastinum is widened and there is loss outline of the adjacent structures due to local mediastinitis.

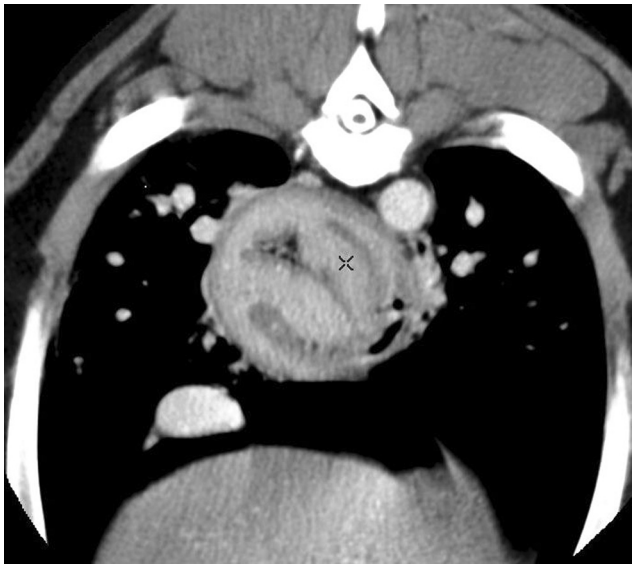


Figure 2: Atypical *S. lupi* oesophageal lesion: A. Transverse contrast-enhanced CT image at the level caudally to the carina of a five year old, female, Cane Corso dog. Noted the striated oesophageal wall thickening (X) which is visible as hyperattenuating contrast enhanced tissue bordered by hypoattenuating layer giving it a layered cake appearance.

Differences in attenuation between pre- and post-contrast medium images were compared by paired t-test. Differences between means were considered significant at $P<0.05$.

RESULTS

Eleven dogs were identified that had lesions which were histologically consistent with benign *S. lupi* oesophageal nodules and which did not show evidence of neoplastic transformation on follow-up examination (CT or radiography) two to four months later. All of these dogs were treated with doramectin (Dectomax, Pfizer, France) at 400µg/kg SC at two weeks intervals for six months (18) and all responded favorably on follow-up examinations. Four were middle-sized crossbred dogs, and seven were purebred dogs (German Shepherd and Golden Retrievers (2 each), Labrador Retriever, Cane Corso and Fox Terrier (1 each)). There were seven females (all neutered and four were males (all neutered). The median age was 8 years (range 5-14 years).

Five dogs had a history suggestive of spirocercosis (e.g., regurgitation, hypersalivation, weight loss and intermittent vomiting); two dogs were presented for investigation for haemothorax; two dogs had a history of recent onset of hind limb weakness without neurological deficits and two dogs were referred for thoracic CT to check for the presence of pulmonary metastases as part of an oncology workup for an unrelated distant tumors.

The main esophageal lesions evidenced by CT were located in the caudal thoracic oesophagus, between the heart base and the diaphragm, in all dogs. The esophageal lesions were located in the dorsal esophageal wall (Figure 1) in 9/11 dogs, and were singular in 8/11 dogs. They were round to oval, pedunculated and clearly demarcated, ranging from 2.5 to 7 cm in diameter with an irregular hypoattenuating eccentric centre surrounded by isoattenuating smoothly demarcated wall (Figure 1). The centre was hypoattenuating to the surrounding esophageal and mass wall; with median pre- and post-contrast images values 55 (range 35-62 & 40-70 respectively). The pre- and post-contrast attenuation characteristics of the centrally-located material within the masses differed significantly ($P<0.05$).

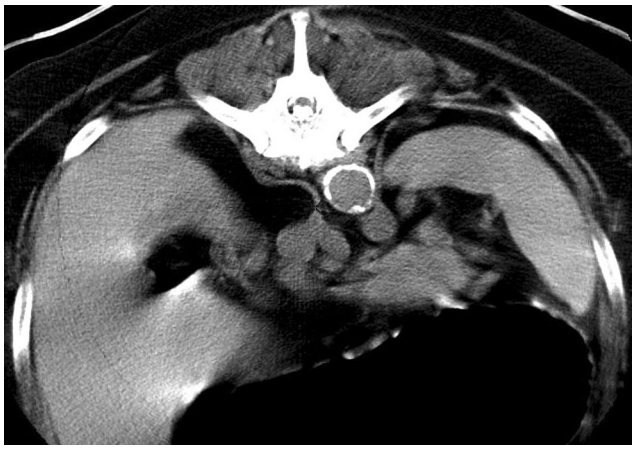


Figure 3: Appearance of aortic wall calcification due to *S. lupi* in a thirteen year old, female, German Shepherd Dog. Non-contrast CT image of the aorta at the level of cranial abdomen, demonstrating thick irregular calcified aortic wall. Note irregular new bone due to spondylitis on the ventral aspect of the 13th thoracic vertebral body.

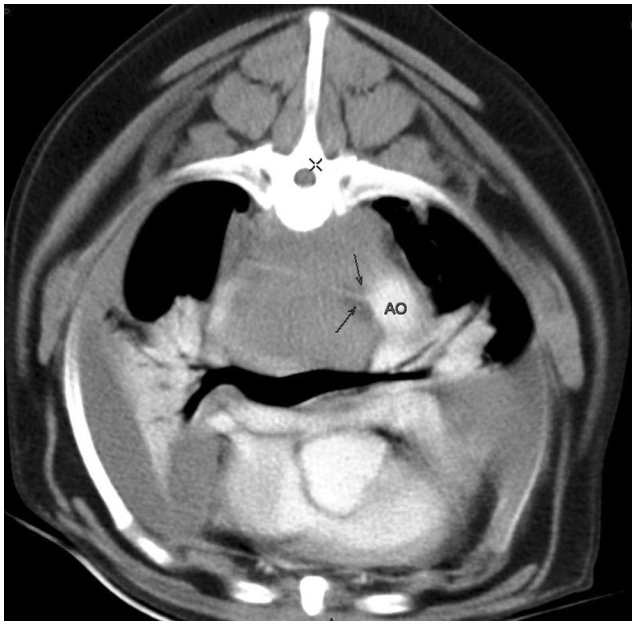


Figure 5: Appearance of aortic wall rupture (slit-like) in a six year old, male, Golden Retriever dog with *S. lupi*. Transverse image of the thorax at the level of the carina. The aortic wall is indistinct and there is striated pattern of contrast leakage from the aorta into a fluid distended mediastinum. Also note the bilateral pleural effusion and associated atelectasis of the lung.

In the contrast-enhanced scans, the mass wall was moderately opacified around the hypoattenuating centre due to contrast uptake in 10/11 dogs (Figure 1).

Two dogs had one additional oesophageal mass, with a similar appearance, but located more cranially, at the level of the heart base. In three dogs the masses were pedunculated, protruding into the esophageal lumen clearly contrasted by the air filled lumen. One dog had a mass which protruded from the dorsal esophageal wall into the mediastinum. None of the masses showed mineralization, and there was no evidence of mediastinal lymphadenomegaly or pulmonary metastasis in any dog. One dog had an atypical diffuse mural thickening of the caudal thoracic esophagus with a striated pattern of hypo- and iso- attenuating stripes (Figure 2). The latter, but not the former, showed distinct contrast uptake.

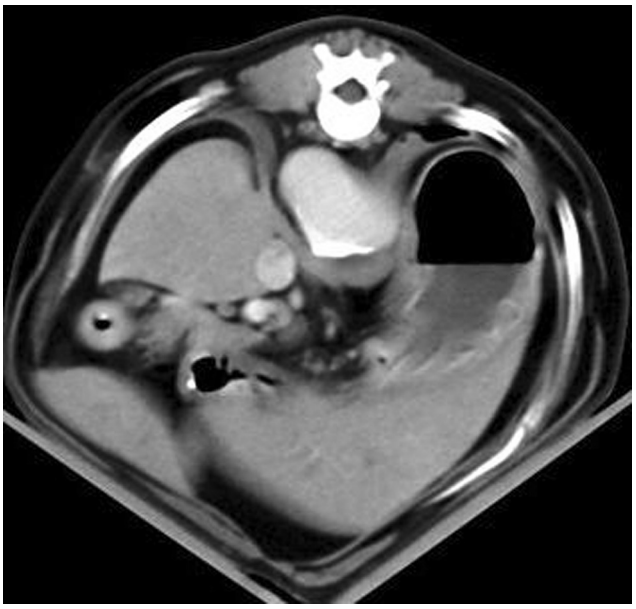
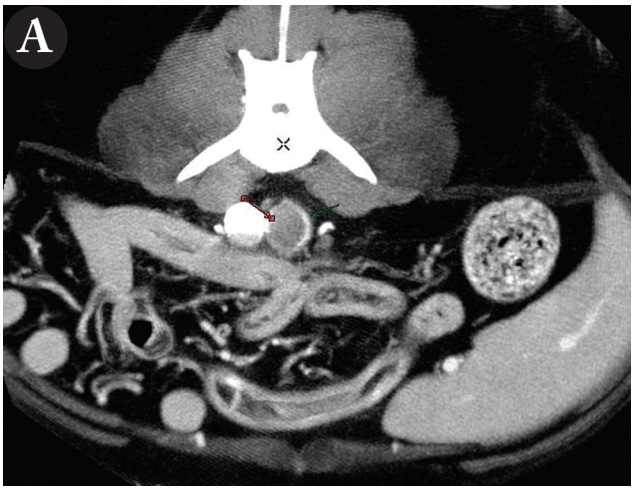


Figure 4: Appearance of aortic aneurysm in a nine year old, medium size cross breed female dog with *S. lupi*. Transverse contrast-enhanced image showing a cylindrical aneurismal dilatation (fuciform) of the thoracic aorta at the level of the diaphragm. Note that due to stagnation of flow the contrast tend to sediment at the site of dilatation.

Spondylotic lesions (thin brush-like to thick periosteal reaction) on the ventral aspect of the vertebrae (Figure 3) distributed from T6 to L2 were present, on CT, in 8/11dogs. One of these also had discospondylitis (visible as irregularly eroded end-plates) at L1-2 intervertebral disc space. Hypertrophic osteopathy was only diagnosed in one case without evidence of a neoplastic condition. Six dogs had granular to plaque-like to curvilinear calcifications of the aortic wall on the CT images (Figure 3), three of which had aneurysmal dilatation at the caudal thoracic aorta (Figure 4).

The two dogs with haemothorax had mediastinal and pleural haemorrhagic effusions (determined by thoracocentesis) was caused by a narrow slit-like rupture of the aortic



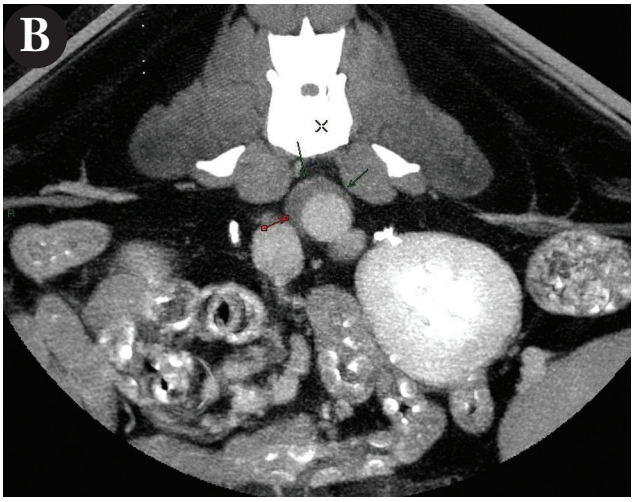


Figure 6: Appearance of thrombosis of the caudal abdominal aorta in a ten year old, male, cross breed dog with *S. lupi*. Transverse (A and B) contrast enhanced CT images of the caudal abdominal aorta. Thrombus fills the caudal abdominal aorta and is seen as hypottenuating intraluminal plague (arrows). On the transverse (B) image taken just cranially to the thrombus (A), a dorsal aortic wall aneurismal dilation is packed with crescent shape hypoattenuating thrombus.

wall (Figure 5). The affected wall was mildly thickened and irregular at the site of the defect, but aneurysmal dilatation and wall calcification of the aortic wall were not noted. One dog which was presented with hind limb weakness had a large intraluminal aortic thrombus with near complete occlusion of the aorta at the level of the caudal mesenteric artery (Figure 6). Immediately cranial to the large thrombus there was a focal dorsal aneurysmal dilatation of the aortic wall, packed with a crescent shaped intraluminal thrombus which was hypoattenuating relative to the aortic wall.

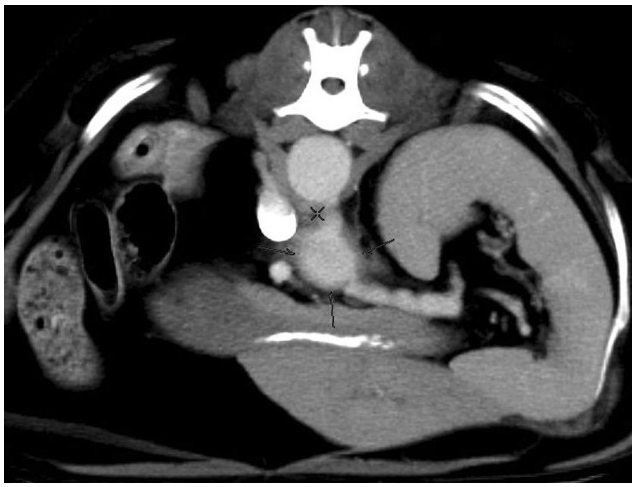


Figure 7: Appearance of a coeliac artery aneurysm in a fourteen year old, male, cross breed dog with a *S. lupi.* A transverse contrast-enhanced CT image taken at the level of the root of the coeliac artery (X). The coeliac artery shows focal saccular dilatation (arrows) close to its origin from the aorta. At the level of the aneurysm the wall of the coeliac artery appears to be thickened, irregular and surrounded by small amount of fluid.

Two dogs had an aneurysmal dilatation of the coeliac artery (Figure 7) close to the aortic junction with an associated thickened, irregular wall. Both had mild aortic wall thickening, one with patchy calcification, but both did not have aortic aneurysms. Two dogs had moderate megaoesophagus and partial consolidation of the right middle lung lobe associated with mixed lung pattern consistent with aspiration pneumonia. One dog had plaque-like pleural thickening of the left middle lung lobe.

DISCUSSION

It is well established that CT studies has several advantages over survey radiography of the thorax including elimination of superimposed anatomy using tomographic and reconstructive images and superior contrast resolution. These properties allow clarification of intrathoracic lesions when radiographic findings are negative or nonspecific (19). Subsequently we expect thoracic CT to be more frequently used in cases suspected of spirocercosis. To date, published studies (10, 20) describing the CT features of spirocercosis are limited including very small number of cases. This study has described the CT features of spirocercosis cases which have not undergone neoplastic transformation.

In this as in a previous study (10), the predominant site

for the *S. lupi* mass was the caudal thoracic esophagus, between the heart base and the diaphragm. Most masses were positioned in the dorsal aspect of the esophagus in proximity of the aorta, suggesting a predilection for a shorter migration tract. In these and previous study the masses tended to be round to oval (10), lobulated with an hypoattenuating (to the wall of the nodule and esophagus), eccentric, irregular or smoothly demarcated centre signifying necrosis or an accumulation of fibrin and neutrophile-rich fluid (2). Statistical analysis of the pre- and post-contrast ROI figures, taken from the hypoattenuating centre of oesophageal masses, showed significant increase in the post contrast-enhanced scans. This finding suggests that the hypoattenuating centre has some viable tissue within it which was not only fluid or necrotic tissue, in agreement with a previous histopathological study of spirocercosis-associated oesophageal lesions (21).

The oesophageal masses were intramural, pedunculated intraluminal or mural protruding into the mediastinum. The pedunculated masses could be better characterized when there was air within the esophagus. Positioning the patient in sternal recumbency was advantageous due to the fact that the masses were mostly dorsal and any intraluminal fluid settling ventrally did not efface the masses. Contrast-enhanced CT examinations clearly demonstrated all the masses, while endoscopy may miss small intramural or mediastinal masses (1). Therefore, contrast agents should be given in all CT examinations where spirocercosis is suspected.

We suggest that the atypical case with segmental, striated caudal oesophageal wall thickening represent fairly early stage of immature adult migration through the esophageal wall before the formation of distinct masses. The striated pattern may be a sequel of a diffuse inflammatory process with associated tissue necrosis due to *S. lupi* infestation.

The CT bone window was extremely sensitive in detecting thin to thick brush-like periosteal reaction on the ventral aspect of the T6 to L2 vertebral bodies indicative of spondylitis, which has high diagnostic value for spirocercosis in endemic areas (1). Additionally, fine curvilinear and plaque-like aortic intimal calcifications were clearly visible. Such changes were often associated with a thickened aortic wall or aortic aneurysmal dilatation and deformity. All the cases showing aneurysmal dilatation of the aorta also had aortic wall plaque-like calcification, suggesting that this is a sequel to a chronic and degenerative process. In contrast, the two dogs noted with aortic slit-like rupture and subsequent haemomediastinum and haemothorax did not demonstrate aneurysmal dilatation or wall calcification and the only noticeable change in these was aortic wall thickening and irregularity at the site of leakage. This observation may suggest that bleeding had occurred at an early disease stage when the larvae had migrated through the aortic wall causing necrosis, hemorrhage and neutrophilic exudation (1). Active aortic bleeding was clearly demonstrated with intravenous contrast administration as streaks of contrast extending from a slit-like defect in the aortic wall into the fluid within the surrounding mediastinum. Therefore thoracic CT angiography should be considered as the examination of choice in suspected ruptured aneurysms.

To the best of our knowledge this is the first report of aneurysmal coeliac artery dilatation documented by CT angiography in dogs. In both cases the aneurysmal dilatation of the coeliac artery was located close to the origin from the abdominal aorta and was associated with a thickened and irregular arterial wall. It is likely that the larval migration within the coeliac arterial wall, subsequent blood vessel wall inflammation and intimal scaring results in aneurysmal dilatation and dissection. Near the aortic origin of the vessel there is slightly higher resistance flow pattern in addition to change in direction of flow which may predispose to focal wall injury if it is weakened by the migrating larvae. One of these dogs had concurrent abdominal haemorhagic effusion diagnoses by ultrasound guided abdominocenthesis. Therefore in endemic areas coeliac aneurysm and subsequent rupture should be included in the differential diagnosis for hemoabdomen.

S. lupi-associated intraluminal thrombus in dogs with thoracic aortic aneurysm was previously reported (6, 20). The present dogs did not show evidence of a disease which might have led to hypercoagulability. CT angiography clearly documented distal thromboembolisation of the abdominal aorta with the presence of focal aneurysmal dilation of the aortic wall, in agreement with similar findings in humans with aortic aneurysm (22). In endemic areas, spirocercosis should be included in the differential diagnosis for distal aortic thromboembolism and subsequent hind limb weakness.

According to this study, hypertrophic osteopathy is not common in non-neoplastic spirocercosis (1/11). This finding is in agreement with Dvir and others (16), who did not observe hypertrophic osteopathy in benign spirocercosis cases.

Nonetheless, in those cases with HO and with the absence of evidence of neoplastic transformation of the oesophageal masses a thorough search for concurrent unrelated neoplastic lesion is warranted. As previously reported (1), aspiration pneumonia, megaoesophagus and pleuritis were sporadically detected in this study as well.

There are several limitations to this study: First, it included a relative small number of cases; second, most cases were diagnosed by endoscopic biopsies which may miss small deep sited neoplastic lesions. Finally, follow-up period was limited to 2-4 months, and therefore the outcome (i.e., cure in benign cases vs. malignant transformation) could not be ascertained.

In conclusion, this study demonstrates the benefits and sensitivity of CT studies for investigating dogs with spirocercosis. CT proved to be extremely sensitive for the investigation of vascular lesions such as arterial aneurysms, rupture and thromboembolisms. It appears that *S. lupi*-induced benign oesophageal nodules typically have eccentric or central hypoattenuating areas surrounded by a soft tissue wall showing moderate to distinct contrast uptake and are non-mineralised. Since CT is an invasive, sometimes cost-prohibitive procedure, further studies investigating its benfits over routine survey radiography and thoracic ultrasonography are warranted.

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