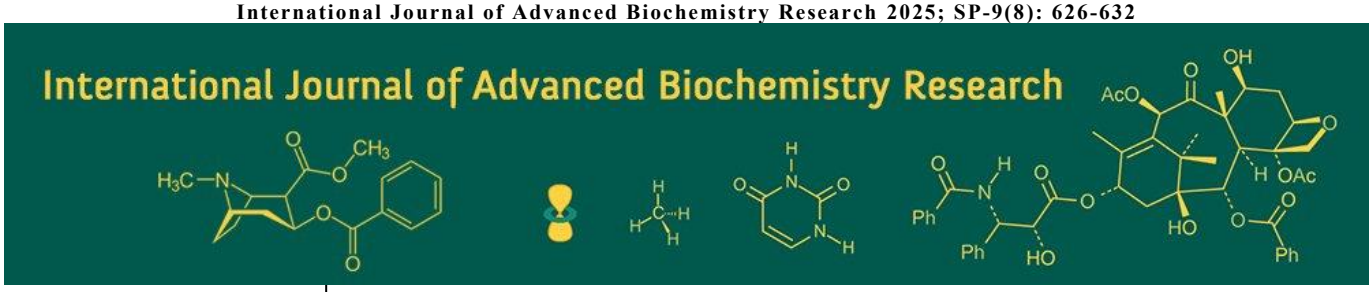

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Canine spirocercosis leading to fatal aortic rupture: A case report

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Abstract
Spirocercosis, caused by the nematode *Spirocerca lupi*, is a prevalent and often insidious parasitic condition in canines in tropical and subtropical regions. This report details a fatal case of aortic aneurysm and rupture in a four year-old non-descript breed dog with a history of exercise intolerance. The disease, transmitted via intermediate coprophagous beetles and paratenic hosts, typically presents with varied clinical signs but can lead to life-threatening outcomes like aortic rupture. Post-mortem examination revealed severe hemothorax, pale mucous membranes, and characteristic aortic nodules (1-2 cm) with hemorrhage, necrosis, and coiled, reddish adult worms. This confirmed spirocercosis as the cause of death due to aortic aneurysm and rupture leading to hypovolemic shock. The literature review highlights the epidemiology, with a higher incidence in outdoor, large breed dogs, and diverse clinical manifestations ranging from subclinical esophageal dysphagia to neoplastic transformation and osteoproliferative abnormalities. Diagnosis often relies on fecal examination and advanced imaging. Treatment primarily involves avermectins, though early diagnosis remains challenging. This case underscores the critical importance of a high index of suspicion and multimodal diagnostic approach for spirocercosis in endemic areas to prevent such catastrophic outcomes and improve canine welfare.

Keywords: Canine spirocercosis, aortic aneurysm and rupture, esophageal granuloma in dogs

Introduction
spirocercosis is a condition caused by nematode *Spirocerca lupi* and shows number of different clinical manifestation. (Bailey *et al.*, 1972) [17] *S. lupi* is distributed in tropical and subtropical areas of the world. Though they are present in numerous animals, this nematode primarily affects carnivores.

Spirocercosis is a parasitic condition in canines caused by the nematode *Spirocerca lupi*, which can lead to a diverse array of clinical manifestations (Bailey *et al.*, 1972) [17]. This nematode is primarily distributed in tropical and subtropical regions globally, and while it can affect numerous animal species, its primary hosts are carnivores. The disease progresses through a complex life cycle involving an intermediate coprophagous beetle and various paratenic hosts, making environmental factors and host behavior significant in its transmission (Fincher *et al.*, 1970) [19].

Review of literature
Epidemiology
Epidemiologically, *S. lupi* has been reported across all continents except Antarctica (Aroch *et al.*, 2015; Chikweto *et al.*, 2012; van der Merwe *et al.*, 2008) [1, 20, 21]. Surveys and reports from domestic dogs and wild canids indicate a higher incidence of infection in stray, urban, adult, large breed, and hunting dogs compared to household pets, small breed dogs, and puppies. This observed pattern is likely due to behavioral factors that increase their exposure to and ingestion of infected intermediate hosts, as well as the length of the nematode's prepatent period (Aroch *et al.*, 2015; Chikweto *et al.*, 2012; van der Merwe *et al.*, 2008) [1, 20, 21]. While the reported prevalence is influenced by diagnostic methods, with higher rates often seen in necropsy surveys compared to fecal coproscopy studies (Aroch *et al.*, 2015; Chikweto *et al.*, 2012; van der Merwe *et al.*, 2008) [1, 20, 21], a breed predilection is also apparent, with the incidence of spirocercosis being greater in medium to large-sized dogs (Ranen *et al.*, 2004) [33].

While domestic canines are recognized as the primary definitive hosts for the spirurid nematode *Spirocerca lupi*, its presence has also been documented in various wild carnivore species (Aroch *et al.*, 2015; Chikweto *et al.*, 2012; van der Merwe *et al.*, 2008) [1, 20, 21]. Global surveillance and reported cases from both domestic and wild canids indicate that *S. lupi* is geographically widespread, with its presence confirmed on all continents with the exception of Antarctica.

Epidemiological studies consistently reveal a higher incidence of *S. lupi* infection in specific canine populations. These include stray animals, urban dogs, adult canines, large breed dogs, and hunting dogs. Conversely, household pets, small breed dogs, and puppies demonstrate a comparatively lower prevalence (Aroch *et al.*, 2015; Chikweto *et al.*, 2012; van der Merwe *et al.*, 2008) [1, 20, 21]. This observed differential susceptibility is likely attributable to behavioral factors of the canine host, specifically their degree of exposure to and subsequent ingestion of infected intermediate hosts. The extended prepatent period of the parasite (the time from infection until eggs are shed in feces) also plays a role, as adult and older dogs have had more opportunities for exposure and parasite maturation. The life cycle of *S. lupi* involves an intermediate host, typically a coprophagous beetle, which ingests the parasite eggs from canine feces. Dogs become infected by ingesting these infected beetles. Paratenic (transport) hosts such as birds, reptiles, and small mammals that consume infected beetles can also transmit the parasite to dogs if ingested.

Furthermore, the reported prevalence rates of *S. lupi* infection across different investigations are significantly influenced by the diagnostic methodology employed. Studies relying on necropsy surveys generally report substantially higher incidences of infection compared to those utilizing fecal coproscopy (Aroch *et al.*, 2015; Chikweto *et al.*, 2012; van der Merwe *et al.*, 2008) [1, 20, 21].

Necropsy studies provide a more accurate reflection of *Spirocerca lupi* prevalence compared to fecal examinations due to the nature of the parasite's life cycle and egg shedding. In India, for instance, necropsy results have indicated a prevalence rate of 23.5% (Ramachandran *et al.*, 1984) [27]. While domestic dogs are the primary hosts, other carnivorous animals can also be affected by spirocercosis (Babero *et al.*, 1965) [18], highlighting a broader host range beyond canids.

Host and Environmental Factors Influencing Incidence: The incidence of spirocercosis tends to be higher in medium to large-sized dogs. This is largely attributed to their tendency to spend more time outdoors, increasing their exposure to infected intermediate hosts, particularly coprophagous beetles (Ranen *et al.*, 2004) [33]. The major epidemiological drivers for this disease are intricate and involve both canine population density and specific environmental conditions. Factors such as soil type and pH, ambient temperature, rainfall patterns, and solar radiation are crucial as they directly influence the survival and proliferation of the intermediate hosts necessary for the parasite's life cycle (Fincher *et al.*, 1970) [19]. Optimal environmental conditions allow for the sustained presence of these intermediate hosts, thus facilitating disease transmission.

Host Demographics and Predisposition: While there isn't a strong consensus on sex or general age predilection for *S. lupi* infection, the nematode's lifecycle dictates that dogs under six months of age, even if infected, typically haven't yet developed the characteristic esophageal lesions or classic clinical signs associated with mature infections (Fox *et al.*, 1988; Wandera, 1976) [30]. This is due to the extended prepatent period required for the parasite to mature and induce significant pathology. However, a breed predilection is evident, with Hounds and other large breed dogs demonstrating a higher incidence of *S. lupi* infection compared to other breeds (Bailey, 1963; Lobetti, 2000) [12, 28, 29]. This likely correlates with their outdoor activities and genetic predispositions.

Interestingly, environmental temperature also appears to influence diagnostic rates. A study at the HUVTH observed a significantly higher number of spirocercosis diagnoses during the colder months (December through April), accounting for 62% of cases, compared to the warmer months (May through November), which saw only 38% of diagnoses ($P = 0.045$) (Mazaki-Tovi *et al.*, 2002) [10]. This seasonal variation in diagnosis could reflect factors such as increased outdoor activity of intermediate hosts in cooler, wetter conditions, or perhaps a delay in clinical manifestation following infections acquired earlier in the year.

Clinical signs

The clinical signs associated with *Spirocerca lupi* infection in dogs can be varied, ranging from subclinical presentations to severe, life-threatening conditions. A review of observed cases highlights the most frequent clinical manifestations. In a specific cohort of infected dogs the five most commonly recorded clinical signs were: Vomiting and/or Regurgitation: Observed in 60% of cases, this is a highly prevalent sign, often indicative of esophageal involvement. Pyrexia (fever): Noted in 24% of dogs, suggesting a systemic inflammatory response. Weakness: Present in 22% of cases, reflecting generalized debilitation. Anorexia (loss of appetite): Affecting 18% of dogs. Melena (dark, tarry stools): Also seen in 18% of cases, pointing towards gastrointestinal hemorrhage, potentially from ulcerated esophageal lesions (Aroch *et al.*, 2015; Chikweto *et al.*, 2012; van der Merwe *et al.*, 2008) [1, 20, 21].

It's noteworthy that twenty of the infected dogs presented with only a single clinical sign. Among these, vomiting and/or regurgitation were the sole symptom in eight dogs. Other solitary signs included paraparesis (partial paralysis of the hind limbs) and weakness (each in four dogs), dyspnea (difficulty breathing) in one dog, and anorexia and diarrhea (each in one dog). Interestingly, two dogs (4%) were entirely asymptomatic, highlighting the possibility of subclinical infection. Typical and Pathognomonic Clinical Signs: Beyond the general symptoms, the typical clinical presentation of spirocercosis often includes: Frequent Vomiting and Regurgitation: These are hallmark signs, particularly regurgitation, which occurs when food is expelled from the esophagus before reaching the stomach, usually without abdominal effort. This is often due to esophageal granulomas causing mechanical obstruction or motility disturbances. Weight Loss: A common sequela of chronic regurgitation, dysphagia, and anorexia, leading to inadequate nutrient intake. Hypersalivation (excessive drooling) and Dysphagia (difficulty swallowing): Directly related to irritation and dysfunction of the esophagus caused by parasitic nodules (Soulsby *et al.*, 1986) [38].

The majority of symptoms in canine spirocercosis are attributable to the development of esophageal granulomas,

which form around the adult worms. These granulomas can undergo neoplastic transformation, developing into sarcomas (e.g., osteosarcomas or fibrosarcomas), making *Spirocerca lupi* a significant oncogenic parasite. Beyond the esophagus, the migrating larvae or adult worms can cause a range of severe pathological changes, including: Aortic Aneurysms: Larval migration through the aorta can weaken the vessel wall, leading to aneurysm formation. Aortic infection is often asymptomatic unless rupture occurs, which can result in acute hemothorax (blood in the chest cavity) and sudden death (Soulsby *et al.*, 1986) [38].

Despite the varied and often severe clinical presentations, it is believed that the fundamental clinical manifestation in many cases of spirocercosis is subclinical esophageal dysphagia. This subtle difficulty in swallowing often progresses to more overt signs such as visible regurgitation, odynophagia (painful swallowing), and hypersalivation, particularly as the esophageal lesions mature and obstruct normal function.

Life-Cycle

The life cycle of *S. lupi* is indirect, requiring an intermediate host, typically a coprophagous beetle, and often involving a variety of paratenic (transport) hosts. Canids become infected by ingesting either infected beetles or paratenic hosts that have consumed infected beetles. Once ingested, the infective larvae embark on a precise migratory journey within the definitive host. They penetrate the gastric mucosa, then migrate along arterial walls, eventually maturing within the thoracic aorta. Following this aortic maturation phase, the adult worms finally relocate to their predilection site: the caudal esophagus. Here, the adult worms reside within characteristic nodules, from which they release larvated eggs that can be detected in fecal samples using techniques like zinc sulfate fecal flotation. (Gal, *et al.*, 2005) [3].

Pathology, Inflammation, and Carcinogenesis

S. lupi elicits a variety of pathological changes across different tissues in infected dogs. Key lesions include aortic scarring, which can lead to aneurysm formation, thoracic vertebral spondylitis, and the development of inflammatory nodules in the caudal esophagus that may unfortunately progress to sarcomas (van der Merwe *et al.*, 2008) [1].

During its larval migration through the aortic wall, *S. lupi* directly causes tissue damage and inflammation. This acute injury is followed by scarring of the aortic wall. Subsequent mineralization of these scarred areas results in increased vascular rigidity. This rigidity, coupled with areas of reduced resistance within the vessel, predisposes to the formation of aortic aneurysms. A serious complication arising from these aneurysms is the formation of blood clots (thrombi) within them. These clots can dislodge, leading to aortic iliac thromboembolism, which can cause acute hind limb paralysis and pain due to arterial occlusion (Gal *et al.*, 2005) [3]. Furthermore, the rupture of an aortic aneurysm is a catastrophic event, often resulting in rapid and fatal bleeding into the chest cavity, known as hemothorax.

Beyond direct tissue invasion, spirocercosis is also associated with osteoproliferative abnormalities in distant anatomical sites. Thoracic vertebral spondylitis is a distinct lesion linked to *S. lupi* infection. It's characterized by a proliferative periosteal reaction on the ventral aspect of the thoracic vertebral bodies, involving the formation of new bone that can eventually bridge adjacent vertebrae. Additionally, hypertrophic osteopathy (HO) is frequently observed, particularly affecting the thoracic limbs of dogs with spirocercosis. In HO, the periosteal membrane surrounding the long bones of the limbs proliferates, creating new bony prominences. This specific presentation is commonly reported in dogs where the esophageal lesions have undergone neoplastic transformation (Dvir *et al.*, 2008) [25]. Given the absence of *S. lupi* migration to these bone sites, it's hypothesized that these osteoproliferative lesions are induced by osteoproliferative growth factors released by the parasite or by inflammatory mediators stimulated by the infection (Kirberger *et al.*, 2013) [26].

In summary, *Spirocerca lupi* is a nematode parasite predominantly affecting the canine esophagus (Bailey, 1972) [17]. While infection can often be subclinical, it's associated with a range of serious conditions. These include esophageal granulomas and their progression to sarcomas, aortic aneurysms, thoracic discospondylitis or spondylosis, hypertrophic osteopathy, and occasionally salivary gland necrosis (Fox *et al.*, 1988; Schroeder and Berry, 1998) [32]. The diverse and severe nature of these pathological outcomes underscores the importance of considering spirocercosis in the differential diagnosis for dogs presenting with unexplained thoracic or systemic disease, particularly in endemic areas.

Diagnosis

Clinical History and Diagnostic Modalities: The historical presentation of *Spirocerca lupi* infection is frequently characterized by chronic vomiting, often persisting for up to three weeks, and a gradual, chronic debilitation of the affected animal. A notable feature of these cases is a poor response to any symptomatic treatments that may have been previously administered, highlighting the need for specific etiological diagnosis.

Fecal Examination for Egg Detection: For definitive diagnosis, particularly by detecting parasite eggs, fecal examination is a primary tool. A solution composed of crystalline zinc sulfate, glycerine, and water has been reported as effective for worm egg flotation (Markovics *et al.*, 1996) [15]. However, the sugar flotation technique is considered more sensitive for identifying *S. lupi* infection, especially in cases with low parasitic burden and consequently low egg shedding intensity. It's crucial to remember that egg shedding can be intermittent, necessitating repeated examinations.

Advanced Imaging and Endoscopy: Beyond fecal analysis, advanced imaging techniques play a significant role. Contrast radiography and computed tomography (CT) are valuable emerging modalities that can help visualize esophageal lesions, spondylitis, and aortic abnormalities. Esophageal endoscopy offers greater diagnostic sensitivity than radiography, allowing for direct visualization of esophageal nodules and inflammatory changes. However, endoscopic biopsies are not consistently sensitive for detecting neoplastic transformation within these nodules, as the mature esophageal granuloma is primarily composed of actively dividing fibroblasts, and sarcomatous changes can be focal or deep-seated, making superficial biopsy unrepresentative.

Ultrasonography

While ultrasonographic evaluation of the abdominal aorta, celiac artery, and gastric wall structure is generally not a sensitive diagnostic marker for *Spirocerca lupi* infection in dogs, the presence of vascular wall irregularity in the abdominal aorta or celiac artery might serve as an indicator of *S. lupi* larval migration (Merhavi *et al.*, 2020) [6]. This suggests its utility may be more in identifying potential secondary effects rather than as a primary screening tool for active infection.

Therapeutic Approaches

Successful treatment of benign spirocercosis primarily relies on avermectins. Doramectin (e.g., Dectomax, Zoetis, France) administered subcutaneously at 400 µg/kg at two-week intervals has been highly successful in managing these cases (Lavy *et al.*, 2002) [34]. However, it's important to note that the use of doramectin in dogs is off-label, and it carries a risk of toxicity in individuals possessing multidrug resistance (MDR1) gene mutations (Yas-Natan *et al.*, 2003) [37]. Consequently, alternative anthelmintic agents have been investigated. These include milbemycin oxime (Kelly *et al.*, 2008) [35] and a spot-on combination product containing 10% imidacloprid and 2.5% moxidectin (e.g., Advocate, AdvantageMulti, Bayer Animal Health, USA) (Segev *et al.*, 2018) [36]. These drugs have demonstrated a good degree of success as both therapeutic and prophylactic agents, although doramectin still appears to have a comparatively higher success rate (Segev *et al.*, 2018) [36].

Currently, doramectin is considered the drug of choice due to its efficacy in killing adult worms and significantly decreasing egg shedding. Despite these advancements in treatment, early diagnosis of *S. lupi* infection remains a challenge, and an ideal, universally established regimen for prophylaxis has yet to be published. This highlights the ongoing need for improved diagnostic methods and preventative strategies to combat this significant parasitic disease in canines.

Matrials and Methods

1. **Animal:** A four year old non-descript carcasses was presented to department of veterinary pathology, Veterinary college, Hebbal. for post mortem examination in the month of September 2023.
2. **History:** history of sudden death. few months ago, animal had a history of exercise intolarence (becomes dull after running and exercise).
3. **Postmortem examination of animal:** thorough post martem examination of carcases was done.

Results

Gross Pathology Findings

The general body condition of the carcass was assessed as good. Rigor mortis was established, indicating a sufficient post-mortem interval. The visible mucous membranes were notably pale, a finding consistent with severe anemia and hypovolemic shock.

Upon opening the thoracic cavity, a substantial accumulation of blood clot (hemothorax) was immediately evident, confirming a major hemorrhage within the pleural space. The heart appeared pale, likely a consequence of significant blood loss and hypovolemia. Examination of the aorta revealed striking pathology: it exhibited multiple nodules, each measuring approximately 1-2 cm in diameter, along with a distinct aneurysm and an obvious rupture site. Transverse sectioning of these aortic nodules unveiled areas of hemorrhage, necrosis, and critically, the presence of adult worms, confirming parasitic involvement. The lungs were collapsed, which is a direct consequence of the hemothorax compressing the pulmonary tissue. All other visceral organs displayed pallor, further supporting the systemic impact of severe blood loss and compromised perfusion.

Diagnosis: Based on these compelling post-mortem findings, particularly the identification of adult worms within the characteristic aortic nodules, the diagnosis is aortic aneurysm and rupture secondary to *Spirocerca lupi* infection (Spirocercosis).

Fig 1: Pale conjuctival mucus membrane

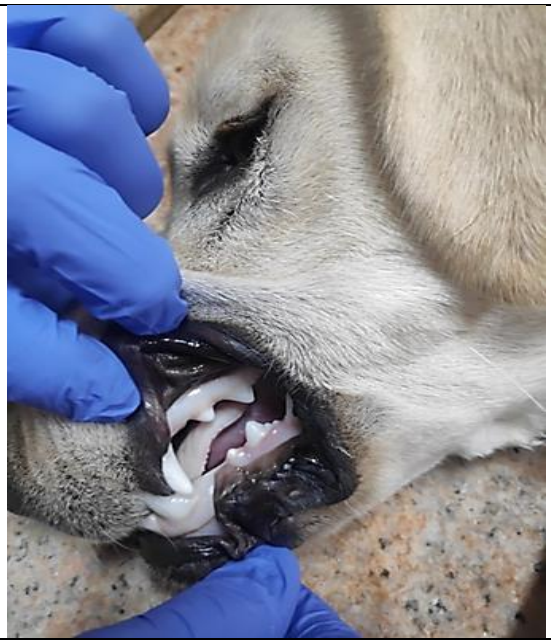

Fig 2: Pale conjuctival mucus membrane

Fig 3: Large amount of clotted blood mass was noticed in the thoracic cavity.

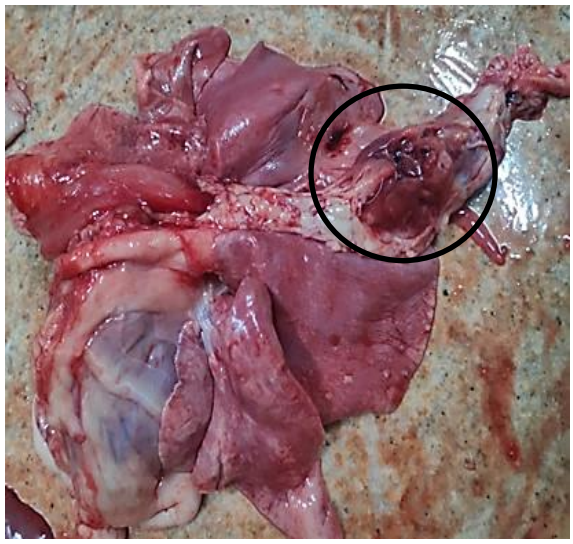

Fig 4: An areas of granulomatous lesion with rupture of vessel noticed on aorta (Circle).

Fig 5: Blood red coloured round worms were extracyed from the aortic granulomatous lesion.

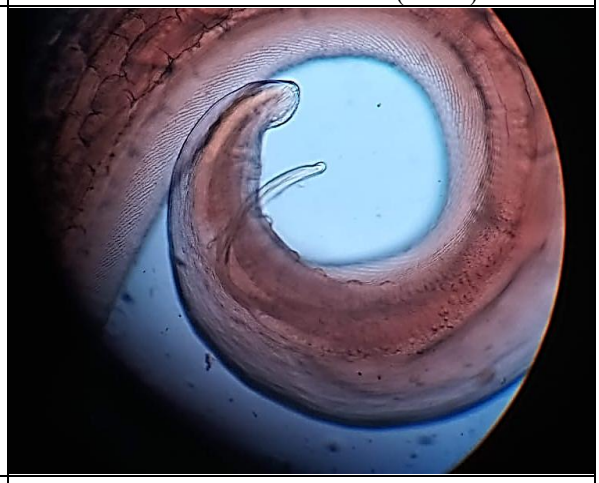

Fig 6: Microscopic examination of worms revealed 2 unequal spicules were noticed.

Discussion

Spirocercosis poses a significant health challenge in areas where the parasite is endemic. As a veterinary pathologist, I can emphasize that early detection is crucial, especially since clinical signs often manifest late in the disease progression, with the notable exception of acute, life-threatening aortic rupture.

In endemic regions, a heightened index of suspicion is warranted for clinical signs highly suggestive of spirocercosis. These include repeated vomiting and regurgitation, dyspnea (difficulty breathing), a persistent cough, and the presence of hypertrophic osteopathy (a paraneoplastic syndrome causing bone proliferation, particularly in the limbs). While esophageal endoscopy offers high diagnostic sensitivity for directly visualizing the characteristic nodules, a quality radiograph can serve as a valuable and cost-effective preliminary diagnostic tool, often revealing esophageal masses, spondylitis, or aortic irregularities.

Based on our findings, for clinical cases in endemic areas presenting with non-specific symptoms like exercise intolerance and fatigue, spirocercosis should be included in the differential diagnosis. This condition can often be initially investigated and potentially excluded with relatively simple diagnostic tests, such as a fecal sample examination for *S. lupi* eggs or a quality thoracic radiograph. Early consideration and diagnostic efforts are vital to improve outcomes in affected animals.

Conclusion

Spirocercosis, caused by *Spirocerca lupi*, poses a significant and often insidious threat to canine health in endemic regions. The complex migratory pathway of the nematode and its subsequent establishment in the host lead to a spectrum of severe pathological lesions, including esophageal granulomas, aortic aneurysms, and thoracic vertebral spondylitis. These lesions can unfortunately culminate in life-threatening complications such as fatal hemorrhage due to aortic rupture, or even neoplastic transformation, highlighting the profound and varied impact of this parasitic infection on affected animals. The often subclinical nature of the disease until advanced pathology or acute events occur underscores the critical need for veterinary practitioners to maintain a high index of suspicion.

Effective management of spirocercosis relies heavily on early and accurate diagnosis, followed by appropriate anthelmintic therapy. Given the non-specific clinical signs, which can range from chronic vomiting and regurgitation to subtle signs of exercise intolerance, a multi-modal diagnostic approach utilizing imaging techniques like radiography and endoscopy, alongside diligent fecal

examinations, is often necessary. Continued efforts in research are crucial to develop more sensitive and accessible diagnostic markers, enhance understanding of the parasite's life cycle and host-parasite interactions, and identify improved therapeutic and prophylactic strategies. These advancements are vital to minimize the severe morbidity and mortality associated with *Spirocerca lupi* infection and ultimately enhance the welfare of canine populations in affected areas.

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