Spontaneous *Crenosoma vulpis* infection in 10 dogs: laboratory, radiographic and endoscopic findings

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Summary

Crenosoma (C.) vulpis infection was diagnosed in 10 dogs aged between 0.5 and 12 years (median 4 years) during a 4-year period. The predominant clinical sign in all dogs was coughing which lasted from 1 day to >4 months. Hematological abnormalities included eosinophilia in 5/9 dogs, basophilia in 3/9 dogs, and mild monocytosis in 6/9 dogs. Thoracic radiographs (n = 9) were normal in 1 dog, showed a mild bronchial or interstitial pattern in 4 dogs, and moderate to marked changes (bronchial-interstitial to alveolar) in 4 dogs. Endoscopic findings (n = 9) varied from mild erythematous bronchitis (n = 3) to marked bronchitis with accumulation of large amounts of mucus (n = 2), irregular nodular mucosal surface (n = 2), accumulation of pus (n = 1), and bronchial hemorrhage (n = 1). Adult worms were observed in 2 dogs. Bronchial lavage cytology revealed inflammation with predominance of eosinophils in 7/10 dogs, eosinophils and neutrophils in 2/10 dogs, and neutrophils in 1/10 dogs. *C. vulpis* larvae were identified in the BAL of 5/10 dogs. Fecal examinations with the Baermann technique was the most sensitive method and positive in all 10 dogs. *C. vulpis* infection has to be considered in the differential diagnosis in dogs of all ages presenting with acute or chronic cough.

Key words: parasites – bronchitis – diagnosis – endoscopy – Baermann

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Zusammenfassung

In einem Zeitraum von 4 Jahren wurde bei 10 Hunden im Alter von 0.5–12 Jahren (Median 4 Jahre) eine *Crenosoma (C.) vulpis* Infektion diagnostiziert. Das Leitsymptom war Husten über einer Dauer von 1 Tag bis >4 Monate. Als hämatologische Veränderungen (n = 9) zeigten sich eine Eosinophilie bei 5, eine Basophilie bei 3 und eine milde Monozytose bei 6 Hunden. Thoraxröntgenbilder (n = 9) waren bei 1 Hund normal, bei je 4 Hunden zeigte sich ein leichtgradiges bzw. mittel- bis hochgradiges bronchointerstitielles Muster. Endoskopische Befunde (n = 9) reichten von milder Bronchitis mit Schleimhautrötung (n = 3) bis hochgradiger Bronchitis mit Ansammlung grosser Schleimmengen (n = 2), unregelmässiger Schleimhautoberfläche (n = 2), Eiteransammlungen (n = 1) und bronchialer Hämorrhagie (n = 1). Bei 2 Hunden wurden adulte Würmer beobachtet. Die zytologische Untersuchung einer Bronchialspülung (n = 10) ergab eine vorwiegend eosinophile Entzündung bei 7, eine gemischte eosinophile-neutrophile Entzündung bei 2 und eine neutrophile Entzündung bei 1 Hund. *C. vulpis* Larven wurden bei 5 Hunden gefunden. Eine Kotuntersuchung mittels Baermann Verfahren war bei allen 10 Hunden positiv und erwies sich damit als empfindlichster diagnostischer Test. *C. vulpis* Infektion muss bei akutem oder chronischem Husten bei Hunden jeden Alters differentialdiagnostisch in Betracht gezogen werden.

Schlüsselwörter: Parasiten – Bronchitis – Diagnose – Endoskopie – Baermann

Introduction

Crenosoma (C.) vulpis is a metastrongyloid nematode parasite of the bronchi and bronchioles of carnivores mainly of foxes and wolves, and occasionally of dogs (Georgi, 1987). The life cycle and pathogenesis of *C. vulpis* have been described (Stockdale, 1970). Briefly, first stage larvae released by adult worms in the host's bronchi are coughed up and passed in the feces. In mollusks which serve

as obligate intermediate hosts they develop into third stage infective larvae. After ingestion of infected mollusks, the third stage larvae penetrate the intestinal wall of the definitive host and reach the lungs via the portal vein, hepatic parenchyma, hepatic vein, heart, and pulmonary circulation. During the prepatent period, which lasts approximately 20 days, the developing larvae and adult worms gradually move up from bronchioles to larger bronchi. Third stage larvae cause interstitial pneumonia, and adult worms cause bronchitis and bronchiolitis (Stockdale, 1970).

C. vulpis has a world-wide distribution (Stockdale, 1970), however, there have been only sporadic clinical case reports of respiratory disease associated with this parasite in dogs (Cobb and Fisher, 1992; Hoff, 1993; Peterson et al., 1993; Neiger et al., 1994; Mc Garry et al., 1995; Shaw et al., 1996; Reilly et al., 2000). All of the described dogs had moderate to marked bronchial and/or interstitial infiltrates on radiographs. Diagnosis was based on endoscopic visualization of adult worms, and/or on identification of larvae in bronchoalveolar lavage (BAL), and/or on presence of larvae on fecal examination using the Baermann technique. In a most recent study from Prince Edward Islands, a high prevalence of *C. vulpis* infection was found in coughing dogs, indicating that at least in certain geographic areas this parasite is of high clinical importance (Bihr and Conboy, 1999). The purpose of the present study was to characterize clinical, hematological, radiographic, endoscopic, BAL, and fecal examination findings in 10 dogs naturally infected with *C. vulpis.*

Animals, materials and methods

Between 1995 and 1998 infection with *C. vulpis* was diagnosed in 10 dogs referred to the Clinic for Small Animal Internal Medicine, University of Zurich from different areas in Switzerland and Southern Germany. Only dogs with a definitive diagnosis were included. In 9/10 dogs complete blood count, biochemical profile, and thoracic radiographs (latero-lateral and ventro-dorsal) were performed. All radiographs were reviewed and graded independently by two of the authors. Bronchoscopy was performed in 9/10 dogs, and bronchial or bronchoalveolar lavage (BAL) were performed in all dogs. Lavage fluid was examined cytologically in all, and bacteriologically in 7 dogs. Bronchoscopically visualized worms were retrieved using a biopsy forceps and kept in 0.9% saline until parasitological identification. In 2 dogs, bronchial biopsies were taken endoscopically and routinely processed for histological examination.

In all dogs fecal parasitological examination was done using the Baermann technique. A single fecal examination was performed in 6 dogs, and two examinations performed on 2 consecutive days were done in 4 dogs. In these latter 4 dogs fecal samples were sent to our clinic by the owner after the dogs had been discharged.

One dog was treated with levamisole (7.5 mg/kg for 2 days). Nine dogs received fenbendazole (25–50 mg/kg/day for 3–10 days). Of these one dog (no. 10) was subsequently also treated with levamisole (7.5 mg/kg), ivermectin (200 ug/kg s/c), antibiotics and prednisolone (1 mg/kg q24h po for 10 days). In 4 dogs fecal examinations were repeated 3–4 weeks after treatment, and in 2 dogs fecal examination was repeated after 3 months, respectively 8 months.

Results

The age of the dogs ranged from 0.5 to 12 years (median 4 years). Four dogs were male, 6 dogs were female. Affected breeds were Labrador Retriever (n = 2), Bernese Mountain Dog (n = 2), Golden Retriever (n = 1), Norwich Terrier (n = 1), Poodle (n = 1), and mongrels (n = 3). All dogs were living in suburban or rural areas, and had regularly access to forests (n = 10) and lakes (n = 2).

The predominant sign in all dogs was coughing which lasted from 1 day to more than 4 months (median 2 months, table 1). Two dogs also showed retching and expectoration of mucus. In addition, one dog (case 10) showed bilateral mucous nasal discharge and sneezing. Three dogs had elevated rectal temperature (39.2, 39.4, and 40.3° C).

Hematological abnormalities included eosinophilia in 5/9 dogs (range 1364–3775/ul, median 1590/ul; normal <1167/ul), basophilia in 3/9 dogs (range 369–384/ul, normal <64/ul), and mild monocytosis in 6/9 dogs (range 702–1107/ul, median 859/ul; normal <560/ul). The biochemical profile was normal in 7/9 dogs. Two dogs showed minimal increase in ALT activity (67 and 85 IU/L, respectively, normal <51 IU/L).

Radiographic, endoscopic, BAL cytological and Baermann examination findings are summarized in table 1. Thoracic radiographs were normal in 1/9 dogs. Abnormal findings in 8 dogs were mild bronchial (n = 3), mild interstitial (n = 1), moderate bronchial-interstitial (n = 1), marked interstitial (n = 1), marked bronchial-interstitial to alveolar (n = 1), and focal alveolar pattern (n=1). Bronchoscopic findings varied between mild bronchitis characterized by mucosal erythema with little or no accumulation of mucus (n = 3) to moderate to severe bronchitis with accumulation of large

Table 1: Signalement, radiographic, endoscopic, BAL-cytology and Baermann examination findings in 10 dogs with C. vulpis infection

Dog no.	Breed	Age (y)	Time to diagnosis[x]	Radiographic pattern	Endoscopic findings	BAL	Baermann
1	Labrador Retriever	1.5	>4 months	Mild bronchial	Moderate mucosal erythema, moderate amount of mucus	Eos Larvae[§]	+ °°
2	Mixed breed (21 kg)	6	2 months	Unremarkable	Mild mucosal erythema, worms visible	Eos Larvae	+
3	Norwich Terrier	0.5	3 weeks	Mild bronchial	Mild mucosal erythema, small amount of mucus	⋆Eos Larvae	+
4	Labrador Retriever	3	2 months	Focal alveolar	Marked inflammation, multiple small whitish nodules	Eos	+
5	Poodle	5	>3 months	Mild interstitial	Purulent exsudate, worms visible	⋆Eos + PMN Larvae	+ °
6	Bernese Mountain Dog	9	1 week	Moderate bronchial-interstitial	ND	⋆Eos	+
7	Mixed breed (23 kg)	12	>3 months	Marked interstitial	Bronchial hemorrhage	Eos + PMN Larvae	+ °
8	Golden Retriever	3	1 day	ND	Marked mucosal erythema, large amount of mucus	Eos	+
9	Mixed breed (29 kg)	2	6 weeks	Marked bronchial-interstitial to alveolar	Mild to moderate mucosal erythema and little mucus	Eos	+ °°
10	Bernese Mountain Dog	11	>3 months	Mild bronchial	Moderate mucosal erythema, irregular mucosal surface	PMN	+

Y = years; [x] = onset of clinical signs until parasitological diagnosis; Eos = predominantly eosinophilic inflammation; Eos + PMN = mixed eosinophilic and purulent inflammation; PMN = predominantly purulent inflammation; ⋆endotracheal wash; [§] endotracheal wash negative 3 months previously; ° 1 positive result in 2 Baermann examinations; °° 2 positive results in 2 Baermann examinations; ND = not done

amounts of mucus (n = 2), irregular mucosal surface (n = 1), nodular inflammation (n = 1), accumulation of pus (n=1), or bronchial hemorrhage (n = 1). Adult worms were visualized in the bronchi of 2 dogs. They quickly disappeared into smaller bronchi during bronchoscopy. Retrieved worms were identified morphologically as adult *C. vulpis* in both cases.

Findings of BAL cytology were inflammation with predominance of eosinophils in 8/10 dogs, eosinophils and neutrophils in 1 dog, and predominantly neutrophils in 1 dog (case 10). Larvae were found in the BAL of 5/10 dogs. Bacteriological culture of the BAL was sterile in 3/7, and revealed non-specific growth in 4/7 dogs, respectively. Bronchial biopsies revealed severe eosinophilic inflammation with smooth muscle hypertrophy in one dog, and mild chronic bronchitis with participation of eosinophils in the other. On fecal examination *C. vulpis* larvae were found in all dogs. In 2/4 dogs from which 2 fecal samples were examined 2 Baermann examinations were negative, i. e. 12 of 14 fecal examinations gave a positive result.

In dog no. 10 that also showed signs of upper airway disease skull radiographs, rhinoscopy, rhinopharyngoscopy, and nasal biopsies were performed. Eosinophilic rhinitis without identifiable underlying cause was found.

All treatment regimens resulted in marked clinical improvement within days in 9/10 dogs. Dog no. 10 continued to show nasal discharge, sneezing and episodic coughing, but no *C. vulpis* larvae could be found on several subsequent fecal examinations. In 4 dogs fecal examinations repeated 3–4 weeks after treatment were negative. Fecal examinations were positive in the 2 dogs repeated after 3 and 8 months respectively. Both dogs did not show any signs of airway disease at that time. These 2 dogs had been treated with fenbendazole at 25 mg/kg daily for 10 days, and 55 mg/kg daily for 3 days, respectively. Both dogs were again treated with fenbendazole (50 and 55 mg/kg/day for 6 days, respectively), and repeated fecal examinations were negative 4 weeks later.

Discussion

The main findings of this study are that infection of dogs with *C. vulpis* may be quite common in Switzerland, and that a non-invasive fecal Baermann examination is more sensitive to yield a diagnosis than bronchoscopy and BAL examination. *C. vulpis* has a world-wide distribution, and foxes are an important host of the parasite. Although urban fox populations had been a well known phenomenon in the UK since 1940, only in the last 15 years high fox densities have also been reported from cities on the continent, e.g. in fox populations from Berlin (Schöffel et al. 1991) and from Copenhagen (Willingham et al., 1996) *C. vulpis* was detected in 35% and 40%, respectively. In Switzer-

land, a considerable increase of the overall fox population was observed over the last ten years (Breitenmoser et al., 1995), and foxes are now commonly seen in urban area (Hofer et al. 2000). Nevertheless, reports of natural infections in dogs are scarce. One explanation may be that dogs only rarely ingest snails, the intermediate host. Furthermore, dogs may be rather resistant to infection, or may only be subclinically infected. We have found *C. vulpis* larvae in feces of dogs several months after clinical cure. It is unknown whether the infections had persisted subclinically after chemotherapy or if these dogs were re-infected. It seems unlikely that we incidentally detected acute re-infection before clinical signs developed, but rather that these dogs remained subclinically infected. Finally, infection in dogs may be underdiagnosed.

Hematological and radiographic findings were not sensitive for the putative diagnosis of *C. vulpis* infection. Eosinophilia and/or basophilia, suggestive of (but not specific for) parasitic infection were present in only 5/9 and 3/9 dogs, respectively. Radiographic abnormalities, though present in 8/9 dogs, were only mild in 4 dogs and to a degree that may even be considered normal for aged dogs (Suter, 1984). The degree of radiographic abnormalities did not correlate with the duration of clinical signs, and radiographic changes were not specific for parasitic infection. Endoscopy combined with BAL-cytology was particularly insensitive for a diagnosis of *C. vulpis* infection. Adult worms were visualized in only 2/9 dogs, and although eosinophilic inflammation was found in 9/10 dogs, larvae were found in only 3 additional dogs. Bronchial biopsies in 2 dogs also showed eosinophilic inflammation, but did not really contribute to the diagnosis. Baermann examination was the most sensitive test in this study. Still, in 2 dogs for which Baermann examinations were performed with 2 fecal samples, one result each was negative, indicating that the sensitivity can be increased by examination of multiple samples per dog.

Minimal elevation of ALT was present in 2 dogs (no. 5 and 9), and may have reflected inflammatory hepatic changes induced by migrating larvae. In experimentally infected dogs distinct histological changes are found early after infection (Stockdale, 1970), but usually no clinical or clinical-pathological evidence of liver disease is recognized at the time when respiratory signs develop. No further diagnostic tests were performed in these 2 dogs to rule-in other causes of ALT elevation.

Clinical cure was achieved in 9/10 dogs with levamisole or fenbendazole using different regimens. Only 1 dog (case no 10) was not cured. This case was different from all the others in many respects, including lack of eosinophilia on BAL-cytology, and clinical and histological evidence of upper airway disease. The underlying disease in this dog and the role of C. vulpis were not resolved. As mentioned, it is unknown if the finding of *C. vulpis* larvae in 2 dogs months after treatment with fenbendazole was representing unsuccessful treatment or re-infection. Whereas levamisole consistently eliminates all parasites in experimentally infected dogs (Stockdale, 1975) such data are not available for fenbendazole. Our present practice is to treat infected dogs with fenbendazole at 50 mg/kg for 5–6 consecutive days.

In summary, infection with *C. vulpis* may be more common in Switzerland than expected and should be considered in dogs of any age presenting with cough of suspected bronchial origin. Eosinophilia is more common in BAL-cytology than in peripheral blood, and should always prompt search for an underlying parasitic infection. Fecal Baermann examination is more sensitive than BAL-cytology to identify the parasite in infected dogs, and treatment with fenbendazole usually results in prompt clinical recovery. In a dog with acute or chronic bronchitis and negative Baermann, a reasonable approach may be to deworm the animal as a diagnostic therapy before performing extensive diagnostic tests.

Infection spontanée par *Crenosoma vulpis* chez 10 chiens: Valeurs de laboratoire et observations radiologiques et endoscopiques

Une infection par *Crenosoma (C.) vulpis* a été diagnostiquée chez 10 chiens âgés de 0.5 à 12 ans (médian 4 ans) au cours d'une période de quatre ans. Le symptôme principal était une toux d'une durée de 1 jour jusqu'à 4 mois. En ce qui concerne les anormalités hématologiques, une éosonophilie était présente chez 5 chiens, une basophilie chez 3 et une légère monocytose chez 6 parmi 9 chiens. Les images radiographiques du thorax étaient normales chez 1 chien alors que chez 4 chiens un pattern bronchointerstitiel léger à modéré était présent. Les résultats endoscopiques (n = 9) ont révélés un évantail entre une légère bronchite avec rougeur des muqueuses (n = 3) jusqu'à une bronchite avec accumulation de grande quantités de mucus (n = 2), une superficie irrégulière des muqueuses (n = 2), une accumulation de pus (n = 1) et une hémorragie des bronches (n = 1). Chez 2 chiens, des vers adultes ont été observés. L'examen cytologique d'un lavage des bronches (n = 10) a révélé principalement une inflammation éosinophile chez 7 chiens, une inflammation combinée éosinophile et neutrophile chez 2 chiens et une inflammation neutrophile chez 1 chien. Des larves de *C. vulpis* ont été trouvées chez cinq chiens. Un examen coproscopique au moyen de la procédure de Baermann était positif chez 10 chiens et s'est avéré être un test diagnostique sensible. Une infection avec *C. vulpis* doit être considérée comme diagnostic différentiel lors d'une toux aiguë ou chronique chez des chiens de tout âge.

Infezione spontanea da *Crenosoma vulpis* in 10 cani: valori di laboratorio, referti radiologici ed endoscopici

In un lasso di tempo di 4 anni è stato diagnosticato in 10 cani di età compresa tra 0,5 e 12 anni (età media: 4 anni) un'infezione da *Crenosoma (C.) vulpis.* Il sintomo principale era una tosse dalla durata di un giorno fino ad oltre 4 mesi. Il quadro ematologico era modificato (n = 9). In 5 cani era presente un'eosinofilia, in 3 una basofilia ed in 6 cani una leggera monocitosi. Le radiografie del torace (n = 9) erano normali in una cane, mentre in 4 cani era presente un disegno broncointerstiziale da lieve-medio fino a molto grave. I reperti endoscopici (n = 9) variavano da una bronchite leggera con arrossamento della mucosa (n = 3) fino ad una bronchite molto grave con accumulo di grandi quantità di muco (n = 2), con la superficie della mucosa irregolare (n = 2), con accumulo di pus (n = 1) ed emorragia bronchiale (n = 1). In 2 cani sono stati notati vermi adulti. L'esame citologico del lavaggio bronchiale (n = 10) ha evidenziato in 7 cani un'infiammazione soprattutto eosinofila, in 2 cani un'infiammazione mista eosinofila-neutrofila ed in un cane un'infiammazione neutrofila. Larve di *C. vulpis* sono state trovate in 5 cani. Un'analisi delle feci tramite il metodo di Baermann è risultato positivo in tutti i 10 cani e si è quindi rilevato il test diagnostico più sensibile. Un'infezione da *C. vulpis* deve essere presa in considerazione nella diagnosi differenziale in cani di ogni età affetti da tosse acuta o cronica.

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