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Department of Veterinary Pathology
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Conference Moderator:
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CASE I – Cat 3 (AFIP 3106179)

Signalment: 18-year-old, spayed female domestic short hair cat (*Felis catus*)

History: This cat initially presented for abnormal gait, difficulty climbing stairs, and inappropriate urination for at least a month. The owner also reported an increase in water intake. Physical examination revealed a thin cat with unkempt hair coat, plantar stance, and a gallop heart rhythm. Additionally, abdominal masses were palpated. Fasting clinical chemistry, hematology and urinalysis samples were obtained and analyzed. The erythron was within normal limits, lymphocyte count was mildly low, and there was a mild azotemia. Electrolyte abnormalities included mildly low potassium and minimally increased calcium. Serum glucose was 360 mg/dl (Normal 64-170). Serum T4 and cortisol concentrations were within normal limits. Urinalysis showed trace protein, moderate glucosuria and bacteria, and large numbers of amorphous crystals with a specific gravity of 1.019. Insulin therapy and treatment for the urinary tract infection were initiated.

Ultrasound findings: Several days after initial presentation, abdominal ultrasonographic evaluation was performed to investigate the abdominal masses. A mass in the location of the left adrenal measured 4.3 by 3.6 cm and a renal cortical mass measuring 3.2 by 2.6 cm were identified within and extending laterally from the right kidney. Due to poor prognosis and response to insulin therapy the animal was euthanized.

Gross Pathology: Abundant adipose tissue was present within the abdominal cavity. The right adrenal was not located; however, the left adrenal was markedly enlarged, multilobulated and pale yellow. The mass expanding from the right renal cortex measured approximately 3 x 3 x 2 cm and was multilobulated, pale pink and firm with several large vessels coursing over the surface. On cut section this discrete mass extended from the cortex and had numerous 1-2 mm diameter cysts containing clear fluid.

Histopathologic Description: Expanding from and within the cortex, adjacent to the corticomedullary junction of the right kidney, was a moderately cellular, multilobulated mass. Lobules were often defined by bands of mature collagen. Numerous tubular structures lined by a single layer of cuboidal cells were supported by moderate amounts of loose collagenous stroma within the lobules (**Fig. 1-1**). The tubular lumena often contained a homogeneous eosinophilic material (proteinaceous fluid), and were dilated in several regions within the mass to several millimeters in diameter. The cuboidal cells lining the tubules were small to medium sized with slight anisocytosis and anisokaryosis with occasional crowding. Nuclei were round with finely stippled chromatin and a single medium-sized nucleolus. Mitotic figures rarely occurred and multinucleation was not noted. In several areas small extensions of neoplastic tubules pushed through the expansion capsule partially surrounding the mass. Rare, small foci of neutrophils were present within the supporting stroma and/or tubules. In the surrounding renal tissue, glomeruli had one or more of the following changes: moderately thickened basement membranes, senechia, thickened Bowman's capsule, and/or diffuse or nodular glomerulosclerosis characterized by hyaline thickening of capillary basement membranes and sclerosis of lobules within tufts and diffuse thickening of mesangium. Tubules also had thickened basement membranes and occasionally were dilated containing proteinaceous fluid. Multifocally the interstitium was expanded by accumulations of lymphocytes and plasma cells that were usually perivascularly oriented around medium-sized vessels. The interstitium throughout the section from papilla to capsule was diffusely expanded by increased amounts of mature collagenous stroma.

Contributor's Morphologic Diagnosis:
1. Severe, chronic, diffuse, membranous glomerulonephritis with glomerular sclerosis
2. Moderate, chronic, multifocal lymphoplasmacytic interstitial nephritis and pyelitis
3. Renal tubular carcinoma
4. Adrenocortical carcinoma (tissue not included)
5. Pancreatic islet amyloidosis (tissue not included)

Contributor's Comment: The submitted renal mass was an incidental finding and unrelated to the clinical condition. Renal carcinomas are uncommon in domestic species with an incidence of up to 0.5 percent in cats although there are reports of lower incidences. Most commonly, renal carcinomas are unilateral, and there does not appear to be a sex or breed predilection. Although the morphology of the cells in the renal mass was relatively benign, the size of the mass and presence of lobules of neoplastic cells invading into vessels warrants a diagnosis of carcinoma rather than adenoma.(6,8)

Clinical diagnosis of diabetes mellitus in this animal was complicated by the presence of a well differentiated adrenal tumor (**Fig. 1-2**). This multilobulated adrenal tumor was densely cellular and composed of large polyhedral cells with abundant finely granular or vacuolated eosinophilic cytoplasm. Nuclei had finely granular chromatin and a single prominent nucleolus. These cells formed irregular trabeculae and nests supported by fine fibrovascular stroma. Mitotic figures were rare and the cells showed moderate anisocytosis and anisokaryosis. Binucleation was common. Multifocally there were areas of necrosis, and single necrotic cells were scattered throughout the mass. The size and histological features of this mass is consistent with a diagnosis of carcinoma.(3) Functional adrenocortical tumors in cats may produce cortisol, progesterone, aldosterone, or estradiol/testosterone. Most cats with hyperadrenocorticism, hyperaldosteronism or hyperprogesteronism are also hyperglycemic.(1,5,10) Unfortunately, many clinical signs for these endocrinopathies are vague and not useful in distinguishing between them. In this case, however, hyperaldosteronism is unlikely due to the mild hypokalemia which is more consistent with hypokalemia associated with an untreated diabetic state. The absence of cutaneous changes (alopecia, dermal fragility) (7) commonly reported in cats with cortisol and progesterone secreting tumors suggests that the mass was also not producing either of these hormones. Additionally, basal cortisol concentrations were within normal limits. Although not associated with hyperglycemia, a report of excessive production of sex steroids in cats increased aggression, thickened skin and vulval hyperplasia, (2) none of which were noted in this animal. Unfortunately due to the euthanasia of this animal prior to complete clinical evaluation, the contribution of the adrenal mass to the clinical condition is unknown.

In the submitted case, pancreatic islet amyloidosis, a characteristic lesion of feline diabetes and Type 2 diabetes in humans (4,9) and in combination with hyperglycemia, strongly supported diabetes mellitus. This finding was characterized by replacement of islet cells throughout the pancreas by an amorphous, pale eosinophilic material consistent with amyloid (**Fig. 1-3**). The changes described above in the renal tissue surrounding the mass and urinalysis are also findings commonly identified in cases of chronic diabetes mellitus, including an ascending bacterial pyelitis.(4)

AFIP Diagnosis:
1. Kidney: Renal adenocarcinoma
2. Kidney: Nephritis, interstitial, lymphoplasmacytic, chronic, multifocal, moderate with fibrosis and pyelitis
3. Kidney, glomeruli: Glomerulonephritis, membranous, global, multifocal, moderate with tubular proteinosis

Conference Comment: There was extensive discussion in the post-conference session regarding the diagnosis of benign versus malignant renal tumor and acknowledgement that diagnosis may be difficult in some cases. As the contributor mentioned, renal tumors are fairly uncommon in cats, and they have not been extensively studied with a subsequent paucity of published literature. This case was reviewed by the AFIP Department of Genitourinary Pathology, and they agreed with the diagnosis of renal cell carcinoma.

Renal adenomas are rare tumors in domestic animals and are usually an incidental finding at necropsy. Grossly, adenomas are well circumscribed, individual tumors normally located in the cortex of the kidney. (8) Multiple adenomas can occur in dogs and cows. In German Shepherds with dermatofibrosis, multiple

renal adenomas may be found as well as renal adenocarcinoma.(8) There are three distinct histologic patterns of renal adenomas: papillary, tubular, or solid.(8)

Renal carcinomas are an uncommon tumor encountered in veterinary medicine, and by the time these tumors manifest clinically in dogs, cats, and horses, they have usually metastasized. Most renal carcinomas are unilateral and often times are located at the pole of the kidney.(8) These tumors historically have been reported to be larger than 2 cm in diameter.(8) Carcinomas have been classified in the histologic subtypes mentioned previously, but the histologic subtype appears to have no bearing on tumor behavior.(8)

Contributing Institution: Eli Lilly and Company, Greenfield, IN

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CASE II – YN06-328 (AFIP 3109441)

Signalment: 3-year-old, female, rhesus macaque, *Macaca mulatta*

History: This animal was born at the Yerkes National Primate Research Center in June 2003. The animal had two incidents of trauma to the hands and feet that resulted in amputation of digits between December 2003 and March 2004. The digit wounds from both episodes healed after routine surgery and treatment with antibiotics and anti-inflammatory drugs, and the animal was returned to her social group. Swelling of both hands, due to subcutaneous deposition of a white material, was reported in March 2006, and the animal was suspected to have calcinosis. The calcified material was debulked surgically and the animal replaced in her group. In October 2006, the white chalky material had returned and the swelling had progressed. Serum ionized calcium level was within normal limits at 1.35 in October 2006. Due to the severity of the condition affecting both hands the animal was humanely sacrificed.

Gross Pathology: The animal weighed 5.3 kilograms at necropsy. Digits from both the hands and feet had been previously amputated and were replaced by multiple, blunt, subcutaneous nodules. On sectioning, these foci contained subcutaneous deposition of a white gritty material. Occasionally, liquefied white material exuded from these nodules.

Laboratory Results: Normal phosphate, calcium and serum ionized calcium levels. No significant pathogen isolated from the skin lesions.

Histopathologic Description: The deep dermis and subcutis are expanded by extensive multifocal deposition of a basophilic granular material (mineral) which often disrupts and replaces the normal dermal architecture (**Fig. 2-1**). The mineral is surrounded by dense aggregates of multinucleate giant cells and macrophages which are occasionally further surrounded by mature fibrous connective tissue. Rare aggregates of degenerate and viable neutrophils are also observed in the dermis. Von Kossa stain revealed

localized deposits of calcium salts in the skin and subcutis. Special stains for bacteria and fungi were negative for any infectious agent in these lesions.

Contributor's Morphologic Diagnosis: Skin, Calcinosis cutis circumscripta

Contributor's Comment: Calcinosis cutis is a rare disorder characterized by deposition of hydroxyapatite crystals or amorphous calcium phosphate in the skin. Depending on the pathophysiologic mechanism, calcinosis can be classified as dystrophic, metastatic or idiopathic.(6) Dystrophic calcinosis is characterized by normal calcium and phosphate serum levels in the presence of tissue damage. The internal organs are not affected. Metastatic calcification occurs in undamaged tissues and is associated with elevated serum phosphate or calcium levels or both.(1) Renal failure, paraneoplastic hypercalcemia, hypervitaminosis D and hyperparathyroidism may develop metastatic deposits of calcium in organs like lung, stomach, kidney, and vasculature.(4) Idiopathic calcification occurs in the absence of evident tissue or metabolic abnormalities.(6)

Dystrophic calcification occurs because of local tissue injuries or abnormalities like alterations in collagen, elastin, or subcutaneous fat, which may precipitate calcification even with normal serum levels of calcium and phosphate.(3) Dystrophic calcification has been divided into calcinosis cutis universalis, which has widespread deposits of calcium, and calcinosis cutis circumscripta, which has only a few localized deposits. (6) Apocrine gland cysts, follicular cysts and skin tumors have been associated with calcinosis cutis circumscripta. Hyperadrenocorticism and diabetes mellitus have been associated with calcinosis cutis universalis.(7)

The gross and histological appearance of the calcified masses in the hands and feet in this case were compatible with a diagnosis of dystrophic mineralization, specifically calcinosis cutis circumscripta. Events potentially leading to these lesions in this macaque included the trauma to digits in hands and feet. Metastatic calcinosis was excluded from the diagnosis due to the presence of normal phosphate, calcium and serum ionized calcium levels. No evidence of mineralization in multiple organs was found on radiographs, grossly at necropsy or histologically. A retrospective analysis done at the Yerkes Primate Center showed 11 cases of calcinosis cutis. Previous trauma was reported at the calcinosis site in digits, tails and in the inguinal area of these animals. In literature, calcinosis cutis circumscripta has been reported in four rhesus macaques without any history of trauma and in a marmoset with a history of trauma.(5)

AFIP Diagnosis: Haired skin: Granulomas, calcareous, multifocal to coalescing (calcinosis circumscripta)

Conference Comment: The different types of calcification and the pathogenesis of these lesions were discussed. Pathologic calcification occurs when calcium salts and small amounts of other trace mineral salts form within tissues. In dystrophic mineralization, such as in this monkey, the end result is the formation of crystal phosphate mineral apatite. There are two phases to the mineralization process dubbed initiation and propagation, and both can occur inside and outside the cell. Dystrophic mineralization can either be a signpost for an area of previous disease or it may cause significant organ dysfunction as seen in valvular disease secondary to calcification.(2)

Hypercalcemia can worsen a nidus of dystrophic calcification. In domestic species there are numerous causes of hypercalcemia. The mnemonic "HARD IONS" may be useful to remember some common causes of hypercalcemia in domestic animals. This is by no means an all inclusive list.

H	Hyperparathyroidism
A	Addison's (Hypoadrenocorticism), Acidosis
R	Renal failure (horses and familial renal disease in Lhasa Apso's)
D	Vitamin D toxicity (rodenticides, hypervitaminosis D, and vitamin D glycoside-containing plants)
I	Immobilization
O	Osteolytic lesions
N	Neoplasia (Apocrine gland tumors, carcinomas in bone, lymphoma, multiple myeloma)

S	Spurious (granulomatous disease, hyperproteinemia, and hemoconcentration)

(1)

Contributing Institution: http://www.yerkes.emory.edu/

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CASE III – S0709546 (AFIP 3109545)

Signalment: Three-month-old, female Saanen goat

History: A 3-month-old, unvaccinated Saanen goat was anaesthetized for the purpose of performing a laparotomy to inject 100 mls of a 20% solution of cornstarch into the abomasum, followed by inoculation of the duodenum with a 200 ml culture of Clostridium perfringens type D (approximately 1 x 10^8 CFU per ml). The animal recovered completely from anaesthesia within 30 minutes after surgery, developed hemorrhagic diarrhea 8 hours post-inoculation, and was euthanized 12 hours later. Necropsy was performed immediately.

Gross Pathology: The wall of the colon was thickened with mild serosal and mesocolonic edema. The colon contained red fluid and the diffusely red colonic mucosa was lined by strands of tan fibrinous exudates (**Figs. 3-1, 3-2)**. Other findings included dilatation and mucosal congestion of the small intestine, and cerebellar coning (herniation of posterior cerebellum into foramen magnum).

Laboratory Results: None

Histopathologic Description: Multifocal to diffuse necrosis of superficial to mid-mucosa is accompanied by formation of a diphtheritic membrane composed of fibrin, mucus, exfoliated epithelial debris, neutrophils, erythrocytes and abundant bacteria (predominantly large bacilli) on the luminal surface of the necrotic mucosa. Clumps of similar fibrinocellular exudate and bacteria also lie free within the lumen. Crypts underlying the necrotic, eroded surface epithelium are distended with catarrhal exudate and lined by necrotic to attenuated epithelium; and associated lamina propria is markedly congested, hemorrhagic and infiltrated by numerous neutrophils. Deep crypts are frequently mildly distended with mucus or catarrhal exudate, and the deep lamina propria and muscularis mucosae are populated by occasional clusters of neutrophils. Scattered lymphatic vessels within the submucosa, tunica muscularis and serosa/mesocolon are distended with proteinaceous fluid. The submucosa is irregularly, mildly/moderately expanded by proteinaceous effusion, infiltrated by small numbers of neutrophils, and populated by scattered clusters of lymphoid cells, and the serosa is mildly, irregularly edematous.

Contributor's Morphologic Diagnosis: Multifocal to diffuse, moderate/severe, pseudomembranous (fibrinonecrotic) colitis, etiology subacute, caprine Clostridium perfringens type D enterotoxemia

Contributor's Comment: Enterotoxemia caused by Clostridium perfringens type D occurs in several animal species but has been studied most thoroughly in sheep. The pathogenesis of C. perfringens type D enterotoxemia in sheep and goats is mostly mediated by epsilon toxin.(2,3)

In sheep, type D enterotoxemia mostly occurs following a sudden change of diet, particularly to feeds rich in fermentable carbohydrates (resulting in large amounts of undigested carbohydrates entering the small intestine). Ovine type D enterotoxemia produces acute to chronic neurologic disease (ranging from sudden death to blindness, opisthotonus, bleating, convulsions and recumbency with paddling) frequently accompanied by respiratory signs and uncommonly accompanied by diarrhea.(3) The neurologic signs are caused by cerebral perivascular proteinaceous edema (observed in 90% of cases), and in chronic cases multifocal, bilaterally symmetrical necrosis of white matter. The respiratory signs are caused by pulmonary edema. There are usually no significant gross or microscopic changes in the intestinal tract of sheep dying from enterotoxemia.(2,3)

Less is known about predisposing factors of caprine type D enterotoxemia. Cases of type D enterotoxemia have occurred in goats on a regular hay diet.(3) In goats with type D enterotoxemia, the most consistent clinical signs are diarrhea, respiratory distress and central nervous system (CNS) signs including recumbency, paddling, bleating and convulsions. Pseudomembranous colitis, similar to that observed in this goat, is the most characteristic postmortem change in caprine enterotoxemia. Histological changes in the brain are not a consistent feature of caprine type D enterotoxemia; however, cerebral vasogenic edema can be observed in some cases of subacute type D enterotoxemia such as this. Accompanying small intestinal lesions are uncommon in goats and were not observed in this case. Cerebellar coning in this goat was considered to be a consequence of cerebral vasogenic edema.(2,3)

In summary, the major difference between type D enterotoxemia in sheep and goats is the response of the intestinal tract to the disease. The reason for the caprine-specific, selective damage to the large intestine has not been determined. It is possible the caprine small intestine is simply more resistant than the large bowel to the effects of the epsilon toxin (or possibly other C. perfringens type D toxins). Antibiotic-associated pseudomembranous colitis in humans, caused by Clostridium difficile, has a similar disease pattern; however, the reason for the lesion distribution has not been identified.(2) It is also possible that the small intestinal mucosa of sheep is more susceptible to damage by epsilon toxin through facilitating absorption of the toxin into the bloodstream with more pronounced systemic effects (CNS lesions). It has also been suggested that the selective damage of the large bowel in goats is a consequence of toxin modification by enzymes in the goat colon. However C. perfringens epsilon toxin, produced as an inactive prototoxin, is activated following cleavage by trypsin. Because trypsin is secreted in the small intestine, epsilon toxin should be activated in the small intestine of both sheep and goats.(2) Transit speed of the intestinal content should not be a factor with regard to the different disease pattern of type D enterotoxemia in sheep and goats because of the similar transit time in both ruminants (normally approximately three hours for small intestine, and 18 hours for large bowel).(2)

AFIP Diagnosis: Colon: Colitis, fibrinonecrotic, multifocal to coalescing, marked, with hemorrhage and superficial cocci and bacilli (**Fig. 3-3**)

Conference Comment: *Clostridium perfringens* type D, also known in the veterinary literature as "overeating disease", or "pulpy kidney disease", is an agriculturally important disease of ruminants. Unfortunately, this disease often affects the hardiest animals on the farm and is caused by excessive intake of starch. The two major types of toxins produced by *C. perfringens* type D include alpha and epsilon, with epsilon being the major contributor to disease.(1) In sheep, epsilon toxin binds to endothelial cells (especially in the brain) leading to focal symmetrical encephalomalacia (FSE). Grossly, lesions often appear in the basal ganglia, thalamus, or substantia nigra. Within the kidney, once bound to distal renal tubular epithelium, the tubules degenerate and the result is a "pulpy kidney". Rapid autolysis of the sheep carcass is also thought to contribute to the "pulpy" appearance of the kidney.

There are four clinical forms of *Clostridium perfringens* type D enterotoxemia in goats: peracute, acute, chronic and subclinical. The peracute form manifests as sudden death with little to no warning. The acute form is characterized by diarrhea and colic of a few days duration, and this turns into the chronic form if the animal does not either fully recover or die within a few days of clinical onset. Mentioned by the contributor, the distal small intestine, cecum, and large intestine are most severely affected in goats.

Histologically, affected areas are hyperemic and may be covered by a layer of fibrin with a moderate number of inflammatory cells present in the lamina propria.(1)

Contributing Institution: California Animal Health and Food Safety Laboratory, UC Davis
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CASE IV – Case 1 (AFIP 3102509)

Signalment: 11-year-old, male, entire, Cavalier King Charles Spaniel, C*anis familaris*, dog

History: This dog presented with a two month history of dyspnoea, lethargy, inappetance, and hemoptysis. Following hospitalization, anthelmintic treatment and concurrent supportive medical therapy (diuretics and corticosteroids), the dog's condition deteriorated acutely with marked respiratory distress. The dog died following respiratory and then cardiac arrest. The dog was submitted for a complete post mortem examination.

Gross Pathology: On post mortem examination, the dog was in good body condition with adequate muscle mass and body fat stores. The lung parenchyma contained multifocal areas of dark red discoloration and consolidation (**Fig**. **4-1**). The tracheo-bronchial lymph nodes were enlarged. The heart was markedly enlarged with a heart to body weight ratio of 1.48% (normal range 0.43-0.99%). The right atrium was dilated. The right ventricular wall was thickened (right atrial dilation and right ventricular hypertrophy). The right ventricle contained a thrombus, which was partially adhered to the endocardium, and numerous slender nematode worms measuring up to 15mm in length.

Laboratory Results: Microscopic examination of a direct faecal smear revealed the presence of nematode larvae consistent with *Angiostrongylus vasorum* larvae. On routine blood count, a moderately regenerative anemia with a hematocrit of 25.5% (reference value: 37-55%) was present. There was an inflammatory leukogram with leukocytosis (27.8 x109/L; reference value: 6.0 -17.1 x109/L), neutrophilia with mild toxic change (16.4 x109/L; reference value: 3.0 -11.5 x109/L) and monocytosis (3.06 x 109/L; reference value: 0.15 - 1.50 109/L). Biochemistry indicated increased total bilirubin (4.8µmol/L; reference value: 0.0-2.4µmol/L).

Histopathologic Description: Lungs: The lung parenchyma was markedly effaced by multifocal to coalescing areas of granulomatous inflammation interspersed with areas of hemorrhage and edema. The granulomatous inflammation was characterized by the presence of histiocytes, multinucleated giant cells of the foreign body type, fibroblasts, lymphocytes and plasma cells, which were arranged concentrically around myriad parasitic larvae and eggs. Very few eosinophils were noted. Larvae were elongate with a thin eosinophilic cuticle and a primitive enteron measuring 10-20 µm in diameter (**Fig**. **4-2**). The thin-walled eggs were ovoid, measured 50-60 µm in diameter and contained either a morula or larva. Larvae and some histiocytes and multinucleated giant cells were also observed within bronchiolar and bronchial lumens surrounded by multinucleate giant cells. Lumens of numerous alveolar spaces and scattered bronchioli and bronchi contained proteinaceous material (edema) and red blood cells (acute hemorrhage). Lumens of some pulmonary arteries contained nematodes measuring about 300 x 150 µm (**Fig**. **4-3**). The nematodes were characterized by an outer smooth cuticle, a hypodermis with accessory hypodermal cords, a coelomyarian musculature, and a body cavity with an oligocytous syncytous intestine and reproductive organs (consistent with adult Metastrongyles, **Fig**. **4-4**). Intravascular nematodes were often surrounded by thrombi, which were partially adhered to the vessel wall. These thrombi were composed of fibrillary eosinophilic material (fibrin) or fibrous connective tissue containing multiple small blood filled channels (organized and recanalized thrombi). The tunica media of numerous pulmonary

arteries was markedly thickened (smooth muscle hypertrophy). The pleura was segmentally thickened by fibrous connective tissue (pleural fibrosis) and contained scattered eggs and larvae, which were surrounded by some histiocytes.

Microscopic examination of additional organs: The parenchyma of tracheo-bronchial lymph nodes, kidneys and brain contained scattered nematode larvae surrounded by granulomatous inflammation.

Contributor's Morphologic Diagnosis: Lungs: Pneumonia, granulomatous with myriad intralesional nematode eggs and larvae and acute hemorrhage and edema
Lungs, pulmonary arteries: Intralesional adult metastrongyle nematodes, thrombosis and media hypertrophy

Contributor's Comment: Microscopic examination together with parasitology showed the presence of verminous pneumonia due to *Angiostrongylus vasorum* (*A. vasorum*) infestation.

A. vasorum is a nematode parasite (superfamily Metastrongyloidae, family Angiostrongyloidae) of which domestic dogs and wild canids are the definitive hosts. Wild foxes serve as an important reservoir for infection in domestic dogs, and natural infection has also been reported in coyotes (*Canis latrans*), wolves (*Canis lupus*) and badgers (*Meles meles*).(3,9) Discrete endemic foci of *A. vasorum* infection in domestic and wild canids are recognized in Europe (France, Ireland, Denmark, Germany, Italy, Spain, Switzerland, Wales, England and Scandinavia), Africa (Uganda), South America (Columbia, Brazil), and more recently in Canada.(4,6)

A. vasorum has an indirect lifecycle. Adult worms live in the pulmonary arteries of the definitive host, and eggs are deposited in the lung parenchyma where they develop and hatch producing larvae (L1). L1 penetrate capillary and alveolar walls moving into alveoli, and the large airways are coughed up and secreted in saliva, or swallowed and then excreted in the feces. Aquatic and terrestrial gastropods ingest larvae and serve as the intermediate host in which larvae mature through L2 to L3 stages. Frogs may serve as paratenic and intermediate hosts.(2) When intermediate or paratenic hosts are ingested by the definitive host, *A. vasorum* larvae migrate via lymphatics or hepatic portal vessels to the right side of the heart where they develop to sexual maturity.

A. vasorum infection is a cause of chronic heart failure and pyogranulomatous interstitial pneumonia in dogs.(5) Aberrant migration of larvae, which was also observed in the present case, can be a cause of complications. Granulomatous foci, with or without association with larvae and eggs, have been reported in the brain, kidney, tracheo-bronchial lymph nodes, adrenal gland, skin, liver, pancreas, peripheral blood, cerebrospinal fluid, pericardial sac, urinary bladder, femoral artery, intestinal tract, thyroid gland, pituitary gland, skeletal muscle, heart, and eye.(4,7,10,11) Hemorrhage into tissues may also be observed. This is thought to occur secondarily to inappropriate activation of the clotting cascade by immune complex formation and compliment fixation directed against the parasites, leading to a consumptive coagulopathy. (12,13)

Interestingly, a low number of eosinophils were observed within the tissue of this case. This may have occurred secondarily to the use of glucocorticoids in the medical therapy for this case. Via their modulatory effects on cytokine production, glucocorticoids are thought to reduce numbers of eosinophils present in the airways by inducing apoptosis (via inhibition of granulocyte macrophage – colony stimulating factor (GM-CSF) and IL-5) and perhaps through decreasing production in the bone marrow.(1)

Strongyle parasites of the respiratory tract in domestic and wild animals include Metastrongyloidean and Trichostrongyloidean parasites. Common Strongyle parasites of verminous pneumonia in domestic species are listed in Table 1.

Nematode parasites can be identified by the presence of a cuticle, hypodermis and underlying musculature (platymyarian or coelomyarian) surrounding the pseudocoelom containing digestive and reproductive tracts.(8) The cuticle of the strongyle-type parasite is usually smooth and the intestine large and composed of a few multi-nucleated cells (syncytous, oligocytous intestine). Metastrongyloidean parasites are characterized by the presence of coelomyarian musculature, which is in contrast to the platymyarian musculature of the true strongyles and trichostrongyles. Adult females may produce either eggs or fully

developed embryos. Metastrongyle L1 larvae are indentified by their distinctive kinked tail morphology and small dorsal spine.

Table 1 Strongyle parasites of the respiratory system of domestic animals [5]

Superfamily	Definitive host	Family	Species	Intermediate host	Paratenic host	Location of adult worms	Notes
Metastrongylidae	Domestic and wild canids	Filaroididae	*Oslerus oslerii*	Direct lifecycle, L1 infective		Tracheal nodules	
			Filaroides (F.) hirthi	Direct lifecycle, L1 infective		Alveoli and respiratory bronchioles	Differentiate from *A. milksi*
		Crensomatidae	*Crensoma vulpis*	Gastropod		Bronchioles and small bronchi	
		Angiostrongyloidae	*Angiostrongylus vasorum*	Gastropod, frog	Frog	Pulmonary arteries and right ventricle	Differentiate morphologically from Dirofilaria spp.
			*Andersonstrongylus (A.) milksi (*prev. *Angiostrongylus milksi, Filaroides milksi)*	Gastropod host proposed, life cycle unknown		Alveoli and respiratory bronchioles	Differentiate from *F. hirthi*
	Domestic cats	Angiostrongyloidae	*Aelurostrongylus abtrusus*	Gastropod	Birds, rodents, frogs, lizards	Terminal and respiratory bronchioles	
	Pig	Protostrongylidae	*Metastrongylus apri M. pudendotectus M. salmi*	Earthworm		Bronchi and bronchioles	
	Sheep, goats	Protostrongylidae	*Muellerius capillaris*	Gastropod		Alveoli, rarely bronchioles	
			Protostrongylus rufescens	Gastropod		Terminal bronchioles	
			Neostrongylus linearis	Gastropod			
Trichostrongyloidea	Cattle	Dictyocaulidae	*Dictyocaulus viviparus*	Direct lifecycle, L1 → L3 in environment		Large bronchi	
	Sheep, goats	Dictyocaulidae	*Dictyocaulus filaria*	Direct lifecycle, L1 → L3 in environment		Small bronchi	

AFIP Diagnosis:

1. Lung, arteries: Endarteritis, chronic, multifocal, severe with thrombi and intravascular adult nematodes consistent with *Angiostrongylus vasorum*
2. Lung: Pneumonia, granulomatous, multifocal to coalescing, severe with hemorrhage and nematode larvae and eggs

Conference Comment: The contributor did an outstanding job of not only describing this particular parasite but also giving an extensive list of other pulmonary parasites in domestic animals.

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