CHAPTER 31

Salmon Poisoning Disease

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Overview of Salmon Poisoning Disease

First Described: Northwestern Oregon, United States, 1814 (Astoria)[1]

Cause: *Neorickettsia helminthoeca,* a gram-negative, obligately intracellular bacteria that belongs to the family Anaplasmataceae

Affected Hosts: Dogs, foxes, coyotes, raccoons, captive bears

Intermediate Hosts: Aquatic snails, fish (especially salmonids)

Geographic Distribution: Coastal areas of Washington, Oregon, northern California, British Columbia, Brazil (2004)

Route of Transmission: Ingestion of the infected trematode vector *Nanophyetus salmincola*, most often in salmonid fish

Major Clinical Signs: Fever, lethargy, anorexia, vomiting, diarrhea, lymphadenomegaly

Differential Diagnoses: Lymphoma, canine parvovirus infection, canine distemper virus infection, granulocytic anaplasmosis, ehrlichiosis, leptospirosis, septic shock, disseminated fungal disease (especially cryptococcosis), hemorrhagic gastroenteritis, dietary indiscretion, gastrointestinal foreign body, pancreatitis, hypoadrenocorticism, inflammatory bowel disease. Appropriate antimicrobial treatment with doxycycline must begin before the diagnosis is confirmed by laboratory testing. Misdiagnosis and delayed or inappropriate antimicrobial drug therapy increase morbidity and mortality.

Human Health Significance: *Nanophyetus salmincola* can cause gastrointestinal disturbances and eosinophilia in humans, but *N. helminthoeca* does not cause human disease.

Etiologic Agent and Epidemiology

Salmon poisoning disease (SPD) is caused by the rickettsial pathogen *Neorickettsia helminthoeca*, which, like other *Neorickettsia* spp., resides within a trematode (fluke) vector for the course of the trematode's life cycle. The trematode vector of *N. helminthoeca* is *Nanophyetus salmincola*, thought to be the most common trematode species endemic to the United States.[2] The disease occurs in dogs, foxes, and coyotes and has also been reported in captive bears, but does not occur in domestic cats.[3-5] SPD is geographically restricted to coastal regions of northern California, Oregon, and Washington in the United States, and southern British Columbia in Canada (Figure 31-1). This reflects the distribution of an aquatic snail, *Oxytrema silicula* (also known as *Juga silicula*), which is an intermediate host of the trematode (Figure 31-1). The snail is prevalent in coastal streams. A similar disease has been described in dogs from Brazil.[6,7] Two related yet antigenically distinct organisms have been isolated from dogs with SPD, *N. helminthoeca* and the Elokomin fluke fever (EFF) agent.[8-12] The EFF agent may be a less pathogenic strain of *N. helminthoeca*.

Dogs usually become infected with *N. helminthoeca* when they ingest encysted trematode metacercariae within uncooked or undercooked freshwater fish, most commonly salmonid fish. The Pacific giant salamander is also a competent second intermediate host. Ingestion of encysted metacercariae is followed by maturation of the trematode, which feeds on the intestinal mucosa and inoculates the rickettsia into the host. The fluke has an oral sucker and a ventral sucker, which are used to grasp host intestinal tissue, although the fluke itself does not cause extensive damage to the intestinal wall.[13] Infected trematode ova are shed in the stool for 60 to 250 days.[14] After several months, miracidia develop within the eggs, hatch, swim away, and penetrate the snail. They then develop into rediae, each of which give rise to many free-swimming cercariae. Thousands of cercariae are released intermittently from the snail. These rapidly penetrate the skin of a fish (or are ingested by the fish), and encyst throughout the fish as metacercariae

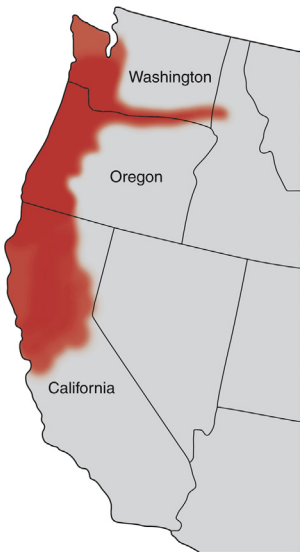

FIGURE 31-1 Geographic distribution of salmon poisoning disease in dogs from the United States. The distribution also extends into the southern portion of British Columbia.

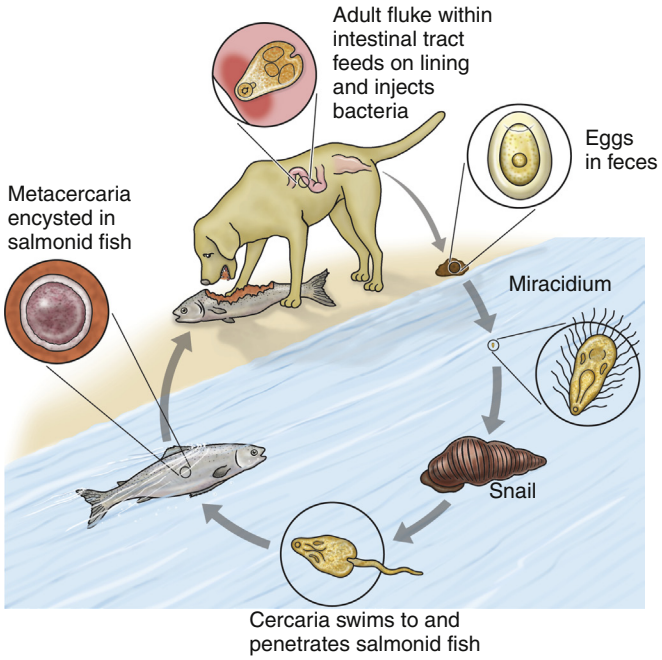

FIGURE 31-2 Life cycle of *Nanophyetus salmincola,* the trematode vector of salmon poisoning disease. The fluke harbors the rickettsial organism throughout its lifecycle.

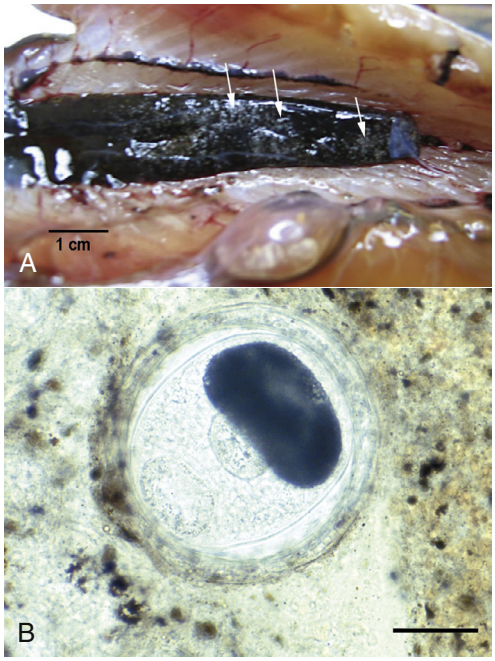

FIGURE 31-3 **A,** "Salt grain" appearance of metacercariae of *Nanophyetus salmincola (arrows)* in the kidneys of a Chinook salmon. (Courtesy Craig Banner, Oregon Department of Fish and Wildlife.) **B,** Wet mount squash of fresh kidney material from a Chinook salmon showing a metacercaria of *N. salmincola*. Bar = 100 µm. (Courtesy Dr. Ronald Hedrick, University of California, Davis.)

(Figures 31-2 and 31-3). Infected fish may contain more than 1000 metacercariae. Infected fish may have visible damage to their skin, and the infection may also interfere with their swimming activity.[15] Dog-to-dog transmission of *N. helminthoeca* has been demonstrated experimentally by mechanical aerosolization or rectal administration of lymph node suspensions or homogenates of rectal mucosa.[16]

Intact male dogs and Labrador retrievers appear to be overrepresented among dogs with SPD,[17] possibly because they are popular with individuals engaged in fishing activities, although dogs of any sex and breed can be affected. Dogs of any age are affected; the median age in one study was 3 years.[17] Dogs develop SPD at any time of year. Occasionally dogs from areas not endemic for SPD develop disease after they ingest fish that is imported from endemic areas.[18]

Most but not all infected dogs have a history of access to or consumption of raw or improperly cooked fish.[17,19] Consumption of any part of the fish, including the entrails and skin, may result in SPD. Supermarket-bought salmon may also be infected.[17] Infection has also been reported after swimming activity, without apparent exposure to fish.[17]

Clinical Features

Signs and Their Pathogenesis

N. helminthoeca replicates within macrophages. This results in a granulomatous inflammatory response within the stomach, intestines, lymph nodes, and spleen. Granulomatous meningitis has also been detected in dogs with SPD.[20,21] The incubation period ranges from 2 to 14 days (median, 7 days), but may be as long as 33 days.[22] The severity of illness varies considerably (Box 31-1). Dogs with peracute infection may be found dead.[17] A marked febrile response is commonly detected (>70% of cases) (Box 31-2) and may reach 107.6°F (42°C).[17]A median rectal temperature of 105°F (40.6°C) was reported in one series of naturally infected dogs.[17] Terminally ill dogs may be hypothermic. Virtually all dogs develop inappetence or anorexia, and lethargy is also common. Vomiting occurs in more than 80% of dogs, and rarely, hematemesis is present.[17] Diarrhea is also common (>70% of dogs) and may be semiformed to liquid in consistency, sometimes containing frank blood, melena, and, less commonly, mucus.[17] Occasionally, a history of diarrhea and vomiting is absent. Other signs include weight loss and increased thirst and urination. Neurologic signs that include mental obtundation, myoclonic twitching, seizures, and apparent neck pain have been reported in fewer than 20% of affected dogs, a primary differential diagnosis being canine distemper virus infection.[17]

BOX 31-1

Signs in the Clinical History of 29 Dogs with Salmon Poisoning Disease

Inappetence or anorexia: 100%
Lethargy: 86%
Vomiting: 86%
Diarrhea: 72%
Hematochezia: 38%
Weight loss: 28%
Melena: 21%
Polyuria and polydipsia: 3%

Physical Examination Findings

Dehydration is frequently noted on physical examination and may be severe. More than 70% of dogs have peripheral

lymphadenomegaly, which may be generalized or involve only some peripheral lymph nodes (see Box 31-2). Lymph nodes may be up to 4 cm in diameter and firm on palpation. Lymphadenomegaly may be absent occasionally, sometimes as a result of lymph node necrosis. Abdominal palpation may reveal pain, and splenomegaly may also be detected. Other abnormalities include tachypnea or labored respirations, tachycardia, scleral or conjunctival injection, and edema that involves the limbs, face, or cervical region.[17] Mucosal pallor, tachycardia, and weak pulses may be present in dogs with hypovolemic shock. Cardiac arrhythmias such as ventricular premature contractions have also been noted, and there may be signs of hemorrhage such as epistaxis and hyphema. Rectal examination may indicate the presence of liquid stool, sometimes accompanied by fresh blood or melena.

Diagnosis

Laboratory Abnormalities

Complete Blood Count

Thrombocytopenia is present in 90% of affected dogs. Anemia is present in up to 40% of dogs with SPD and generally occurs as a result of gastrointestinal hemorrhage. More commonly, the CBC shows evidence of lymphopenia, thrombocytopenia, or neutrophilia, frequently with bandemia (Table 31-1). Uncommonly, neutropenia occurs.[17] Toxic changes may be present within neutrophils, and immature monocytes may occasionally be found in the peripheral blood. Despite the association with helminthiasis, eosinophilia has not been documented.

BOX 31-2

Physical Examination Findings in 29 Dogs with Salmon Poisoning Disease

Peripheral lymphadenomegaly: 74%
Fever: 73%
Dehydration: 65%
Abdominal pain: 28%
Tachypnea or labored respirations: 24%
Tachycardia: 24%
Neurologic signs: 17%
Weak pulses: 17%
Splenomegaly: 14%
Scleral injection: 14%
Mucosal pallor: 10%
Hypothermia: 5%

Serum Chemistry Profile

Hyponatremia and hypokalemia are the most common electrolyte abnormalities in dogs with SPD and result from gastrointestinal losses that occur with vomiting and diarrhea (Table 31-2). Low ionized calcium concentrations may be detected in some dogs, possibly as a result of decreased intestinal absorption. Hypoalbuminemia is present in most (>80%) dogs. Hypoglobulinemia and hypocholesterolemia occur in fewer than 25% of dogs with SPD, but may become profound. Abnormal liver enzyme activities may be present, the most common of which is increased ALP activity,[17,20] but increases in the activity of ALT and AST may also occur. Hyperbilirubinemia is present in fewer than 20% of dogs. Azotemia can be evident in dogs with severe dehydration.

Urinalysis

Bilirubinuria and proteinuria are frequently detected on urinalysis in dogs with SPD.[17] Uncommonly, cylindruria and glucosuria are present, perhaps as a result of renal injury secondary to impaired renal perfusion. Microscopic hematuria occurs in some dogs, possibly reflecting underlying coagulopathies that can occur in dogs with SPD.

Clotting Function

Evaluation of clotting function in some dogs with SPD shows evidence of disseminated intravascular coagulation. Abnormalities include increased PT or APTT, increased fibrin degradation products, and decreased antithrombin activity.[17]

Diagnostic Imaging

Plain Radiography

Abdominal radiographs may be unremarkable or reveal fluid-filled small intestines; decreased serosal detail; and less frequently, hepatomegaly or splenomegaly. Thoracic radiographs

TABLE 31-1

Hematologic Findings in 29 Dogs with Salmon Poisoning Disease

Test	Reference Range	Percent below the Reference Range	Percent within the Reference Range	Percent above the Reference Range	Range for Dogs with Salmon Poisoning Disease	Number of Dogs Tested
Hematocrit (%)	40-55	39	61	0	22-53	23
Neutrophils (cells/μL)	3000-10,500	4	53	43	728-26,224	23
Band neutrophils (cells/μL)	Rare	0	40	60	0-6825	20
Monocytes (cells/μL)	150-1200	9	61	30	42-3290	23
Lymphocytes (cells/μL)	1000-4000	78	22	0	0-2070	23
Eosinophils (cells/μL)	0-1500	0	100	0	0-690	21
Platelets (cells/μL)	150,000-400,000	90	0	10	10,000-446,000	20

TABLE 31-2

Findings on Serum Biochemistry Analysis in 29 Dogs with Salmon Poisoning Disease

Test	Reference Range	Percent below the Reference Range	Percent within the Reference Range	Percent above the Reference Range	Range for Dogs with Salmon Poisoning Disease	Number of Dogs Tested
Sodium (mmol/L)	145-154	59	36	5	133-161	22
Potassium (mmol/L)	4.1-5.3	41	59	0	3.7-5.0	22
Chloride (mmol/L)	105-116	9	77	14	98-118	22
Bicarbonate (mmol/L)	16-26	20	15	65	11-28	20
Calcium (mg/dL)	9.9-11.4	83	17	0	7.2-10.9	23
Phosphorus (mg/dL)	3.0-6.2	9	74	17	2.7-13.0	23
Creatinine (mg/dL)	0.5-1.6	4	4	13	0.4-3.3	23
BUN (mg/dL)	8-31	0	83	17	8-110	23
Albumin (g/dL)	2.9-4.2	83	17	0	0.9-3.8	23
Globulin (g/dL)	2.3-4.4	26	70	4	1.6-4.7	23
Cholesterol (mg/dL)	135-345	22	69	9	79-408	23
Total bilirubin (mg/dL)	0-0.4	0	83	17	0-3.1	23
ALT (U/L)	19-70	4	74	22	17-1,443	23
ALP (U/L)	15-127	0	39	61	29-985	23

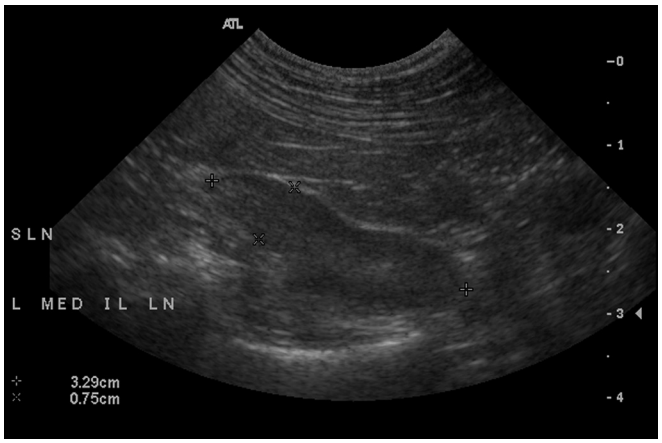

FIGURE 31-4 Enlarged and hypoechoic abdominal (medial iliac) lymph nodes as detected using abdominal sonographic examination in a 9-year-old male German shepherd dog with salmon poisoning disease.

are typically unremarkable or show reduction in size of the intrathoracic vasculature, consistent with hypovolemia.

Sonographic Findings

Abdominal ultrasound examination of dogs with SPD often shows mild or moderate generalized abdominal or mesenteric lymphadenomegaly, as well as splenomegaly with a mottled splenic echotexture. Some dogs that lack peripheral lymphadenomegaly have abdominal lymphadenomegaly on ultrasound examination,[17] and ultrasound-guided aspiration of enlarged abdominal lymph nodes can be helpful for diagnosis in dogs that lack peripheral lymphadenomegaly. Lymph nodes develop a rounded appearance with a hypoechoic or hypoechoic mottled echogenicity (Figure 31-4). Fluid-distended intestinal loops, sometimes with wall thickening, corrugation, hypermotility, or hypomotility, may be documented. Uncommonly, hepatomegaly or a small amount of free peritoneal fluid is identified.

Microbiologic Tests

Diagnostic assays for SPD are summarized in Table 31-3.

Diagnosis Using Fecal Examination

SPD can be diagnosed when operculated trematode eggs are found in fecal specimens of dogs with consistent clinical signs, which appear within 5 to 8 days after the ingestion of infected fish. Although the sensitivity of centrifugal zinc sulfate fecal flotation for detection of *N. salmincola* ova in dogs with SPD is similar to that of fecal sedimentation, some dogs that test negative by one method test positive using the other, so the sensitivity of fecal examination for diagnosis is maximized by performing both centrifugal zinc sulfate fecal flotations and fecal sedimentation together. In one study, 93% of dogs with SPD tested positive for *N. salmincola* ova using a combination of fecal flotation and fecal sedimentation.[17] False negatives may occur when the duration of illness is shorter than the prepatent period of *N. salmincola* or when light fluke burdens are present. The finding of fluke ova on fecal examination may not be diagnostic of SPD, because dogs may be infected with trematodes that do not harbor the rickettsia, and ova may be shed for months after recovery. Nevertheless, *N. salmincola* ova were detected in only 0.2% of more than 1800 fecal flotations in dogs seen at a teaching hospital in an endemic area, and all positive test results were in dogs suspected to have SPD. Thus, the specificity of fecal examination for a diagnosis of SPD appears to be extremely high.[17]

Centrifugal zinc sulfate fecal flotation may reveal co-infections with other gastrointestinal parasites, which can complicate

the clinical picture. Co-infections with *Dipylidium caninum* and *Trichuris vulpis* have been reported in dogs with SPD.[17]

Cytologic Diagnosis

In addition to fecal examination for trematode ova, SPD can be diagnosed following cytologic examination of peripheral lymph node aspirates, or ultrasound-guided aspirates of abdominal lymph nodes or the spleen. Cytologic findings consist of histiocytic hyperplasia and lymphoid reactivity. Rickettsial organisms are 0.3–µm cocci or coccobacilli and may be seen in large numbers within the cytoplasm of macrophages. They resemble granular to amorphous material of a uniform blue color using Wright's stain, occasionally forming loose clusters of organisms (morulae) (Figure 31-5).[17,22,23] In as many as one quarter to one third of dogs, rickettsial organisms are not identified. The presence of histiocytic hyperplasia should alert the clinician to the possibility of SPD. Organisms may also be absent in dogs with a recent history of antimicrobial therapy.

Serologic Diagnosis

Serologic tests for *N. helminthoeca* antibodies or antigen are not available on a commercial basis for veterinary practitioners. Antibodies to *N. helminthoeca* can cross-react serologically with those of *Ehrlichia* spp., so it is possible that dogs with SPD might test positive using serologic tests for *Ehrlichia* spp. (provided enough time had elapsed for antibody formation to occur).[24] In one study, most dogs with SPD that were tested for antibodies against other rickettsial pathogens did not seroreact to *Ehrlichia canis* or *Anaplasma phagocytophilum*.[17]

Molecular Diagnosis Using the Polymerase Chain Reaction

Specific PCR assays have been used to detect the DNA of *Neorickettsia helminthoeca* in clinical specimens from affected dogs.[17] Real-time PCR assays for *N. helminthoeca* are available from some veterinary molecular diagnostic laboratories and can be performed on blood, lymph-node, or splenic aspirates and possibly fecal specimens from dogs with SPD in order to confirm the diagnosis. More research is required to understand the sensitivity and specificity of PCR assays for diagnosing SPD in dogs, including the optimum specimen type for testing.

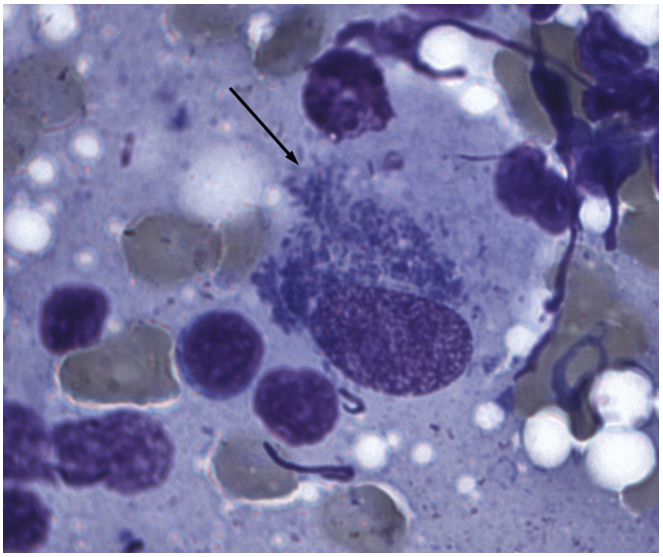

FIGURE 31-5 Lymph node aspirate from a dog with salmon poisoning disease. Note the large histiocyte that contains granular coccoid organisms consistent with *Neorickettsia helminthoeca*.

TABLE 31-3

Diagnostic Assays Available for Salmon Poisoning Disease in Dogs

Assay	Specimen Type	Target	Performance
Fecal sedimentation combined with zinc sulfate centrifugal fecal flotation	Feces	*Nanophyetus salmincola* ova	Specificity nears 100% when performed by a parasitologist. Sensitivity probably >90%. Eggs are light brown, ovoid, operculate at one end and measure 0.087 to 0.097 mm × 0.038 to 0.055 mm.
Cytology	Lymph-node or splenic aspirates	Detection of *Neorickettsia helminthoeca* within macrophages	Sensitivity >70% when performed by a veterinary clinical pathologist. Sensitivity may be improved by examination of aspirates from multiple lymph node. Organisms within macrophages may be confused with debris or hemosiderin. Other changes include lymphocytic reactivity and histiocytic hyperplasia.
Histopathology	Biopsy or necropsy specimens, especially lymph nodes, spleen, gastrointestinal tissues	*N. helminthoeca* within macrophages	Organisms may be stained with Giemsa. Antimicrobial therapy can lead to false-negative results.
PCR	Blood, lymph-node or splenic aspirates, tissue specimens, feces	*N. helminthoeca* DNA	Well validated assays that are specific for *N. helminthoeca* are not available commercially. Optimum specimen type unknown. Antimicrobial therapy may lead to negative PCR results.

Pathologic Findings

Gross Pathologic Findings

Gross necropsy findings in dogs with SPD consist of enlargement of lymphoid tissues, including the tonsils, thymus, lymph nodes, and spleen. Lymph nodes may be yellowish and edematous and may contain white foci that represent foci of granulomatous inflammation. Petechial hemorrhages may be noted on the lymph nodes, the gastrointestinal tract, pancreas, gallbladder, and urinary bladder. The gastrointestinal tract may be thickened and contain white foci. The lumen of the intestinal tract may contain free blood (Figure 31-6, *A*). Flukes are only 0.8 to 1.1 mm long and 0.3 to 0.5 mm wide[25] and may not always be visible grossly.

Histopathologic Findings

Lymphoid tissues show marked depletion of lymphoid follicles, and subcapsular and medullary sinuses are filled with histiocytes, the cytoplasm of which can contain numerous rickettsial organisms, which occasionally form clusters within vacuoles. Organisms are readily appreciated using Giemsa stain (see Figure 31-6, *C*). Lymph node and splenic necrosis may also be present.[17,22] Inflammatory nodules that contain lymphocytes, plasma cells, and infected histiocytes expand the lamina propria of the gastrointestinal tract and extend into the submucosa. Parasites consistent with *N. salmincola* may be found embedded in the mucosa, primarily within the duodenum (see Figure 31-6, *B*).[16,21] Nevertheless, flukes are not always found using histopathology in dogs that die from SPD, even in the absence of anthelmintic therapy.

One dog that died of SPD had widespread and multiple thromboses involving numerous organs with associated tissue infarction. Granulomatous meningitis has been described at necropsy in dogs that were experimentally infected with *N. helminthoeca*.[20]

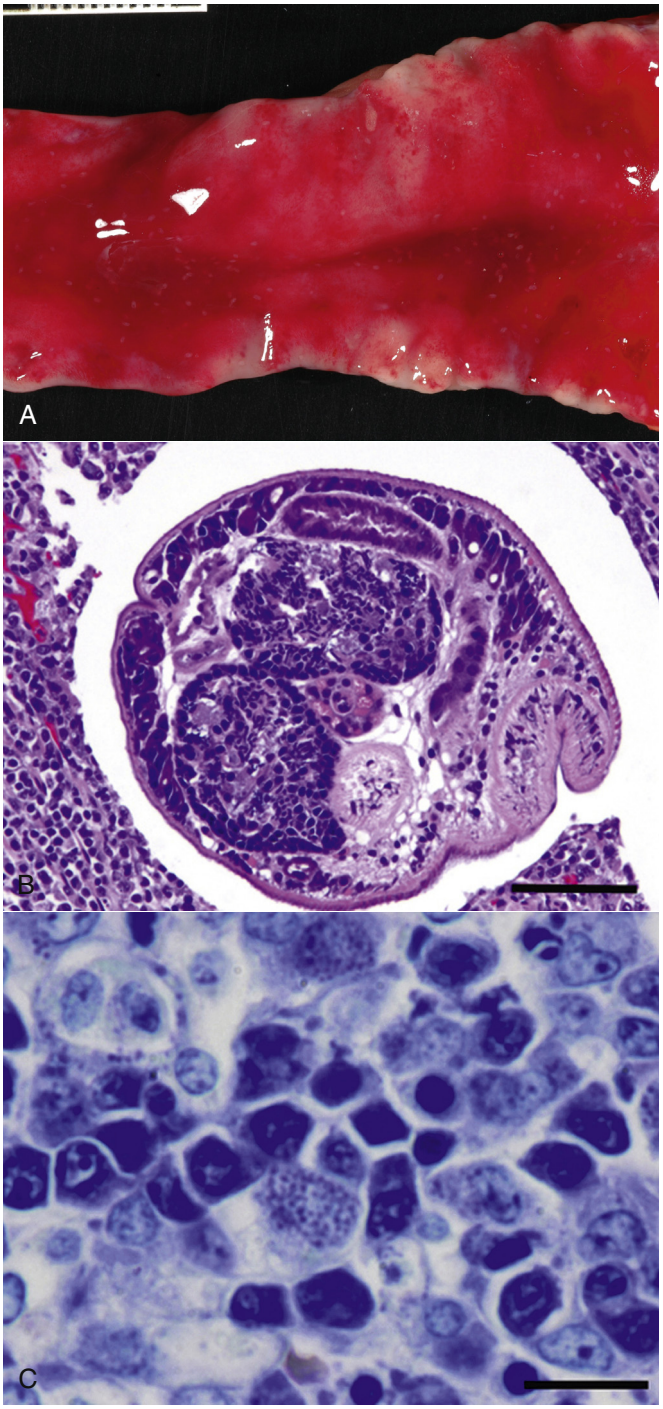

FIGURE 31-6 **A,** Intestinal mucosa of an 8-month-old female spayed Maltese mix dog that died of salmon poisoning disease. The intestinal wall was thickened and the contents were dark red and mucoid. (Courtesy University of California, Davis Veterinary Anatomic Pathology Service.) **B,** Duodenum. A transverse section of an adult *Nanophyetus* fluke is embedded within the intestinal villi. H&E stain. Bar = 200 µm. **C,** Lymph node, medullary sinus from a dog with salmon poisoning disease. Many histiocytes have intracytoplasmic clusters of coccobacilli less than 1 µm in diameter. Giemsa. Bar = 5 µm. (B and C from Sykes JE, Marks SL, Mapes S, et al. Salmon poisoning disease in dogs: 29 cases. *J Vet Intern Med* 2010;24[3]:504-513, 2010.)

Treatment and Prognosis

The treatment of choice for SPD is doxycycline, tetracycline, or oxytetracycline, which should be given for a minimum of 7 days. Administration of tetracyclines is generally associated with clinical improvement within 24 hours, and signs resolve within 1 to 4 days.[17] Dogs that are vomiting may require treatment with parenteral tetracyclines. Clinical improvement has also been reported following treatment with enrofloxacin and parenteral trimethoprim-sulfamethoxazole. Antimicrobials that do not appear to be effective include first-generation cephalosporins, penicillins, aminoglycosides, chloramphenicol, and metronidazole.[17] Although complete clinical recovery may occur without anthelmintic treatment, the fluke infection should be treated with praziquantel after initial recovery from SPD (Table 31-4).

Dogs with mild signs or infrequent vomiting may respond well to treatment with oral tetracyclines alone, whereas those with more severe disease often require hospitalization for IV antimicrobial and crystalloid fluid therapy (see Table 31-4). Oral antimicrobial therapy can be continued once vomiting ceases. The presence of severe hypovolemia or hypoalbuminemia may necessitate treatment with colloids such as fresh frozen plasma, dextrans, or hetastarch. Packed RBC or whole blood may be required for dogs with severe anemia. Treatment with total or partial parenteral nutrition may also be required if vomiting is persistent and does not respond to antiemetics such as metoclopramide, maropitant, or ondansetron. Close monitoring of hematocrit, albumin, electrolytes, acid-base status, renal parameters, and coagulation parameters may be required in some severely affected dogs. Blood cultures should be considered in dogs with severe hemorrhagic diarrhea and

TABLE 31-4

Antimicrobials Used to Treat Salmon Poisoning Disease in Dogs

Drug	Dose (mg/kg)	Route	Interval (hours)	Duration (days)
Doxycycline	5	PO, IV	12	7-14
Tetracycline	22* 7	PO IV	8 8	7 7
Oxytetracycline	7-10*	PO, IV	8	7
Praziquantel†	10-30	PO	24	1-2

*Reduce dose in renal failure; may cause teeth discoloration in young animals. Monitor for nephrotoxicity (cylindruria).
†For treatment of fluke infection.

abnormal perfusion parameters, after which treatment with broad-spectrum parenteral antimicrobial drugs should be commenced.

Prolonged hospitalization may be required for dogs that develop complications such as cardiac arrhythmias, intussusceptions, adverse reactions to tetracyclines, disseminated intravascular coagulation, or septicemia.[17,19] In a study of dogs evaluated at a tertiary referral hospital, death or euthanasia occurred in 14% of 29 dogs with SPD.[17] The mortality may be lower in dogs seen in primary care practice, providing appropriate treatment can be administered. In general, early treatment is associated with an excellent prognosis. Without treatment, death can occur within 5 to 10 days.

Immunity and Vaccination

Animals that recover from SPD are immune to reinfection with the same strain of *N. helminthoeca*,[22,26,27] but challenge with an alternate strain (then the EFF agent) results in disease, and antibodies fail to cross react with the alternate strain. This may explain why SPD has been reported to occur more than once in some dogs.[17,22] No vaccine is available.

Prevention

N. helminthoeca metacercariae are effectively destroyed by proper cooking or freezing of infected fish. Ingestion of raw fish by dogs in endemic areas should be discouraged, and dog owners in endemic areas should be educated about the disease. Dogs that have eaten raw fish from an endemic area, or those swimming in rivers or lakes in these areas, should be watched carefully for signs of lethargy, vomiting, or decreased appetite that occur within 2 weeks of exposure. If multiple dogs are simultaneously exposed to a source of *N. helminthoeca*, and one dog develops SPD, treatment of the other dogs in the group with 7 days of doxycycline should be considered. Medical equipment used in the treatment of dogs with SPD should not be reused on other patients without proper sterilization.

Public Health Aspects

Human infection with *N. helminthoeca* has not been reported. However, humans may become infected with the fluke, *N. salmincola*, after consumption of poorly cooked fish. Most humans are subclinically infected, although abdominal discomfort, diarrhea, vomiting, weight loss, nausea, and peripheral eosinophilia may occur.[28]

CASE EXAMPLE

Signalment: "Herman," 9-year-old male German shepherd dog from Sacramento, CA (Figure 31-7).

History: Herman's owner reported a 2-day history of inappetence, lethargy, and one episode of vomiting. The dog had been drinking normally. There had been no diarrhea, coughing, sneezing, or increased thirst and urination. The owner also reported that Herman ate turkey and chicken that contained bones 3 days before the onset of illness. He was normally fed a strict diet of rabbit- and potato-based prescription dog food and grilled salmon because of atopic dermatitis. Herman was sometimes fed salmon scraps from the local supermarket, which the owner grilled briefly. He had not traveled out of his local area. He was up to date on vaccinations, which included vaccines for distemper, hepatitis, parvovirus, and rabies.

Current Medications: Lincomycin 29 mg/kg PO q12h; trimeprazine tartrate 0.2 mg/kg PO q48h; prednisolone 0.1 mg/kg q48h for atopic dermatitis.

Other Medical History: Herman had been diagnosed with hip osteoarthritis using pelvic radiography 8 months earlier. Controlled weight loss was the recommended treatment. He was cryptorchid, and the abdominal testicle had been removed when he was a young dog. The descended testicle was still present.

Physical Examination:

Body Weight: 51.5 kg

General: Quiet, alert and responsive. Ambulatory on all four limbs. T = 104.3°F (40.2°C), HR = 108 beats/min, RR = 60 breaths/min, mucous membranes pink, CRT = 1 s.

Integument: A full, shiny haircoat was present and there was no evidence of ectoparasites.

Eyes, Ears, Nose, and Throat: No significant abnormalities were noted. A mild amount of brown waxy debris was present within both ear canals.

Musculoskeletal: A body condition score of 6/9 with symmetrical muscling was noted. Mild to moderate pelvic limb weakness was identified.

Cardiovascular: Strong femoral pulses were noted. No murmurs or arrhythmias were detected on thoracic auscultation.

Respiratory: An increased respiratory rate with increased abdominal effort was present.

Gastrointestinal and Genitourinary: Abdominal palpation revealed a tense abdomen, with abdominal splinting, and splenomegaly. There was one descended testicle, which was smooth with no masses. No abnormalities were detected on

Continued

FIGURE 31-7 "Herman," a 9-year-old male German shepherd dog with salmon poisoning disease.

rectal examination. Soft feces were present in the rectum, and the prostate was palpable and symmetrical.

Lymph Nodes: Marked peripheral lymphadenopathy was present. Mandibular, superficial cervical, and popliteal lymph nodes were all 3-4 cm in diameter and firm.

Laboratory Findings:

CBC:

HCT 40.4% (40-55%)
MCV 65 fL (65-75 fL)
MCHC 36.6 g/dL (33-36 g/dL)
WBC 4240 cells/µL (6000-13,000 cells/µL)
Neutrophils 3689 cells/µL (3000-10,500 cells/µL)
Lymphocytes 466 cells/µL (1000-4000 cells/µL)
Monocytes 42 cells/µL (150-1200 cells/µL)
Platelets 74,000 platelets/µL (150,000-400,000 platelets/µL).

Serum Chemistry Profile:

Sodium 141 mmol/L (145-154 mmol/L)
Potassium 4.0 mmol/L (3.6-5.3 mmol/L)
Chloride 112 mmol/L (108-118 mmol/L)
Bicarbonate 13 mmol/L (16-26 mmol/L)
Phosphorus 2.8 mg/dL (3.0-6.2 mg/dL)
Calcium 9.9 mg/dL (9.7-11.5 mg/dl)
BUN 15 mg/dL (5-21 mg/dL)
Creatinine 1.1 mg/dL (0.3-1.2 mg/dL)
Glucose 86 mg/dL (64-123 mg/dL)
Total protein 6.9 g/dL (5.4-7.6 g/dL)
Albumin 3.6 g/dL (3.0-4.4 g/dL)
Globulin 3.3 g/dL (1.8-3.9 g/dL)
ALT 108 U/L (19-67 U/L)
AST 109 U/L (19-42 U/L)
ALP 105 U/L (21-170 U/L)
Creatine kinase 381 U/L (51-399 U/L)
GGT < 3 U/L (0-6 U/L)
Cholesterol 296 mg/dL (135-361 mg/dL)
Total bilirubin 0.4 mg/dL (0-0.2 mg/dL)
Magnesium 1.7 mg/dL (1.5-2.6 mg/dL).

Urinalysis: SGr 1.048; pH 6.0, 2+ protein (SSA), 1+ bilirubin, 1+ hemoprotein, no glucose, 0-1 WBC/HPF, 20-30 RBC/HPF, rare ammonium biurate crystals, many lipid droplets

Imaging Findings:

Thoracic Radiographs: The cardiovascular and pulmonary structures appeared within normal limits. A mild diffuse bronchial pattern throughout all lung fields was considered consistent with the age of the patient. Marked spondylosis deformans was present throughout the thoracic spine.

Abdominal Ultrasound: The liver had a diffuse, coarse echotexture. The spleen was markedly, diffusely enlarged and had a diffuse hypoechoic, mottled echotexture. The prostate gland was enlarged and had multiple small anechoic cysts within its parenchyma. One testicle was present in the scrotum and had a striated, heterogenous echotexture. A second inguinal or intra-abdominal testis was not observed. Multiple enlarged, hypoechoic inguinal lymph nodes were present (see Figure 31-3). A large (2.5 cm), round, hypoechoic mass with a focal area of mineralization was present in the cranial abdomen caudal to the liver and most likely represented a lymph node. Multiple enlarged, hypoechoic sublumbar lymph nodes were observed. The splenic lymph nodes were enlarged and mildly hypoechoic.

Cytology Findings: Cytology of ultrasound-guided splenic aspirate: splenic stromal clumps contained increased numbers of plump histiocytes and many large clumps of hemosiderin. Histiocytes were also present in moderate numbers throughout the smear, often in clumps, and often mildly vacuolated. They were occasionally erythrophagocytic and often contain hemosiderin. Interpretation: moderate to marked histiocytic inflammation.

Cytology of popliteal lymph node aspirate (see Figure 31-5): moderate reactive lymphoid hyperplasia with pyogranulomatous inflammation was identified. Rare histiocytes were present that contained intracellular small coccoid purple-blue structures that were organized individually and in clusters. These were consistent with *Neorickettsia helminthoeca* organisms.

Fecal examination: Fecal flotation: Negative for parasites.
Fecal sedimentation: *Nanophyetus salmincola* ova, <1 per 10× field

Diagnosis: Salmon poisoning disease

Treatment: Doxycycline, 5 mg/kg PO q12h for 14 days. This was associated with resolution of fever and inappetence within 24 hours of starting treatment. By 7 days after diagnosis, Herman's owner reported that Herman was completely back to his normal self.

Comments: This dog was diagnosed with SPD based on the presence of characteristic cytologic findings on examination of a lymph node aspirate, together with the detection of *N. salmincola* ova in the stool. The case was unusual because the dog was infected after ingestion of incompletely cooked supermarket-bought salmon, which the dog had been fed for years without developing illness. Although the splenic aspirate contained inflammatory cells typical of those seen in SPD, organisms could not be convincingly documented.

SUGGESTED READINGS

Mack RE, Bercovitch MG, Ling GV, et al. Salmon poisoning disease complex in dogs—a review of 45 cases. Calif Vet. 1990;44:42-45.

Sykes JE, Marks SL, Mapes S, et al. Salmon poisoning disease in dogs: 29 cases. J Vet Intern Med. 2010;24(3):504-513.

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