

# Primary bacterial peritonitis in dogs and cats: 24 cases (1990–2006)

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**Objective**—To determine clinical characteristics of primary bacterial peritonitis (infection of the peritoneal cavity with no identifiable intraperitoneal source of infection) and compare characteristics of primary and secondary peritonitis in dogs and cats.

**Design**—Retrospective case series.

**Animals**—24 (primary peritonitis) and 60 (secondary peritonitis) client-owned dogs and cats.

**Procedures**—Data from medical records of dogs and cats with primary and secondary peritonitis were reviewed for descriptive information regarding primary peritonitis and for comparison between the 2 forms of peritonitis.

**Results**—15 dogs and 9 cats met inclusion criteria for primary peritonitis, and 49 dogs and 11 cats met inclusion criteria for secondary peritonitis. The most common historical findings in dogs and cats with primary and secondary peritonitis were lethargy, vomiting, and anorexia. Dogs with secondary peritonitis more often developed peritoneal exudates than those with primary peritonitis, and dogs with primary peritonitis were more often infected with gram-positive bacteria than those with secondary peritonitis. No difference in outcome was detected between all animals with primary versus secondary peritonitis; however, dogs with secondary peritonitis treated with surgery were more commonly discharged than those with primary peritonitis treated with surgery.

**Conclusions and Clinical Relevance**—Differences in primary and secondary peritonitis related to historical, physical examination, and clinical laboratory findings; bacteriologic findings; peritoneal effusion characteristics; and outcome were detected. However, larger case numbers are needed before alternative recommendations, such as avoidance of surgery, can be made. (*J Am Vet Med Assoc* 2009;234:906–913)

Causes of peritonitis are numerous and include infectious agents, such as bacteria, viruses, and fungi, as well as noninfectious agents. Categorization of bacterial peritonitis into primary, secondary, and tertiary forms is regular practice in human medicine.<sup>1–4</sup> Historically, the terms primary peritonitis and spontaneous bacterial peritonitis have been used interchangeably<sup>1,2,4</sup>; however, debate exists about whether these terms truly represent the same disease state.<sup>5</sup> Regardless, primary peritonitis is defined as an infection of the peritoneal cavity with no identifiable intraperitoneal source of infection or history of a peritoneal penetrating injury.<sup>1,2</sup> Secondary peritonitis is the most commonly encountered form of peritonitis and is caused by intraperitoneal leakage of bacteria, most commonly from the gastrointestinal tract. Secondary peritonitis has been extensively reported in veterinary medicine.<sup>6–8</sup> Tertiary peritonitis is persistent or recurrent peritonitis after an adequate attempt has been made to control either primary or secondary peritonitis.<sup>3,4</sup>

In human medicine, the clinical suspicion of primary peritonitis is often based on clinical features and results of peritoneal fluid analysis.<sup>2</sup> Primary peritonitis,

in most cases, is associated with diseases causing ascites, most commonly cirrhosis.<sup>9,10</sup> Patients may complain of abdominal pain and often have increased temperature and decreased gastrointestinal motility.<sup>2,9</sup> Peritoneal effusion analysis that reveals a neutrophil count  $\geq 250$  to 500 cells/mL, an acidic effusion ( $\text{pH} \leq 7.34$ ), or both, in combination with the described clinical signs, is considered sufficient to make primary peritonitis the major differential diagnosis.<sup>1,2,10</sup> If a suspicion of secondary peritonitis remains because of poor response to antimicrobial treatment or the presence of a polybacterial infection in the peritoneal cavity, further diagnostic tests to rule out causes of secondary peritonitis, such as imaging studies (ultrasonography, computed tomography, and magnetic resonance imaging), are pursued.<sup>10</sup> When primary peritonitis has been diagnosed, treatment with appropriate antimicrobials and supportive care with a focus on preventing disease-related complications are initiated. Surgery is not routinely pursued.<sup>10</sup>

Reviews of peritonitis in the veterinary literature have designated feline infectious peritonitis as the most common form of primary peritonitis in companion animals<sup>11,12</sup>; however, in a few case reports,<sup>13–15</sup> cases have been described that are suggestive of primary bacterial peritonitis. In those cases,<sup>13–15</sup> the bacteria cultured from the peritoneal cavity included *Clostridium limosum*, *Chlamydia psittaci*, and *Salmonella enterica* serogroup Typhimurium.

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The true characterization of primary peritonitis, specifically of bacterial origin, in dogs and cats has not been evaluated. The main purpose of the study reported here was to characterize primary bacterial peritonitis in dogs and cats with a particular focus on signalment, clinical findings (historical and physical examination), clinical laboratory abnormalities, bacteriologic findings, peritoneal effusion characteristics, surgical and necropsy findings, and outcome. Primary and secondary peritonitis were also compared across several categories to determine whether differences existed between those 2 forms of peritonitis.

## Materials and Methods

**Criteria for selection of cases**—A computerized medical record search of dogs and cats admitted to the Matthew J. Ryan Veterinary Hospital of the University of Pennsylvania for septic bacterial peritonitis from 1990 to 2006 was performed. For the purpose of this study, primary peritonitis and spontaneous bacterial peritonitis were considered synonymous; this concept has been supported in several publications.<sup>1,2,10,12</sup> The cases were categorized into either primary or secondary peritonitis on the basis of the inclusion criteria.

Requirements from 2 categories had to be met for inclusion as a case of primary peritonitis. First, intracellular bacteria were identified on cytologic evaluation of peritoneal fluid by a clinical pathologist or bacteria were grown in culture from a sample of the peritoneal fluid obtained during surgery. Second, cases were included if either surgical or postmortem evaluation confirmed that an intraperitoneal source of bacterial leakage was lacking. Cases of secondary peritonitis were identified by use of the first criterion and also had a confirmed source of intraperitoneal bacterial leakage identified either during surgery or at necropsy. Cats with feline infectious peritonitis were not included. In addition, animals with a recent history (< 12 months) of peritoneal dialysis catheter placement, penetrating injuries, or trauma were not included among cases of primary peritonitis.

**Procedures**—Information retrieved from the medical records included signalment, historical and physical examination findings, clinical laboratory results, bacteriologic findings, peritoneal effusion characteristics, surgical findings, and outcome. Comparisons were made between cases of primary and secondary peritonitis in several categories, including signalment, historical findings, physical examination findings, clinical laboratory results, bacteriologic findings, peritoneal effusion characteristics, and outcome.

**Statistical analysis**—Values for continuous variables are given as mean  $\pm$  SD or median (range) depending on whether the data were normally or not normally distributed, respectively. Proportions are described as percentages, and comparisons between proportions were made by use of the Fisher exact test. For all comparisons, values of  $P < 0.05$  were considered significant. A statistical software program<sup>a</sup> was used for all analyses.

## Results

**Primary peritonitis**—Fifteen dogs met inclusion criteria for primary peritonitis. Dog breeds included

German Shepherd Dog ( $n = 3$ ), Golden Retriever (3), Yorkshire Terrier (2), mixed breed (2), and 1 each of American Staffordshire Terrier, Borzoi, Boxer, Dachshund, and Old English Sheepdog. Mean age of dogs was  $6.4 \pm 4$  years, and there were 6 castrated males, 5 sexually intact males, 3 spayed females, and 1 sexually intact female. Nine cats met inclusion criteria for primary peritonitis. Cat breeds included domestic shorthair ( $n = 8$ ) and domestic longhair (1). Mean age of cats was  $7.7 \pm 4$  years, and there were 6 castrated males, 2 spayed females, and 1 sexually intact female.

The most common historical findings in dogs were lethargy (14/15), vomiting (13/15), anorexia (9/15), and diarrhea (7/15). Prior to evaluation for primary peritonitis, none of the dogs had a history of gastrointestinal tract disease, heart disease, or liver disease. Pertinent physical examination findings in dogs included tachypnea (13/15), depressed mentation (12/15), signs of abdominal discomfort (11/15), high rectal temperature (9/15), inadequate hydration (7/15), poor nutritional condition (6/15), tachycardia (6/15), and abdominal distention (5/15).

The most common historical findings in cats were lethargy (9/9), anorexia (6/9), and vomiting (5/9). Prior to evaluation for primary peritonitis, none of the cats had a history of gastrointestinal tract disease, heart disease, or liver disease. Pertinent physical examination findings in cats included tachypnea (8/9), inadequate hydration (8/9), signs of abdominal discomfort (7/9), abdominal distention (6/9), depressed mentation (6/9), low rectal temperature (5/9), high rectal temperature (2/9), and poor nutritional condition (2/9).

The most common abnormalities detected via CBC in dogs included neutrophilia (8/15), thrombocytopenia (8/15), leukocytosis (6/15), anemia (4/15), and leukopenia (1/15; **Table 1**). The most common abnormalities detected via serum biochemical analyses in dogs included high alkaline phosphatase activity (9/15), hyperlactatemia (8/15), high aspartate transaminase activity (7/15), hypoalbuminemia (5/15), and high alanine transaminase activity (5/15).

The most common abnormalities detected via CBC in cats included thrombocytopenia (7/9), anemia (3/9), and leukopenia (3/9; **Table 2**). The most common abnormalities detected via serum biochemical analyses in cats included hypoproteinemia (9/9), hypoalbuminemia (8/9), high aspartate transaminase activity (8/9), hyperlactatemia (6/9), hyponatremia (5/9), hypermagnesemia (3/9), hyperglycemia (3/9), high alanine transaminase activity (3/9), and high alkaline phosphatase activity (2/9). Three cats were tested for FeLV and FIV, and all results were negative.

The peritoneal effusion was characterized in 12 dogs and classified as a transudate in 1 dog, a modified transudate in 2 dogs, and an exudate in 9 dogs. Median nucleated cell count was 6,855 cells/ $\mu$ L (range, 1,570 to 133,500 cells/ $\mu$ L), and mean total protein concentration of the effusion was  $3.11 \pm 0.6$  g/dL.

The peritoneal effusion was characterized in all 9 cats and was classified as a transudate in 3 cats, a modified transudate in 1 cat, and an exudate in 5 cats. Median nucleated cell count was 3,150 cells/ $\mu$ L (range, 500 to 149,500 cells/ $\mu$ L), and mean total protein concentration of the effusion was  $2.55 \pm 0.5$  g/dL.

Table 1—Clinical laboratory data of dogs with primary or secondary peritonitis.

Variable	Primary peritonitis				Secondary peritonitis			
	No. of dogs	Median	Range	Reference range	No.	Median	Range	P value
PCV (%)	15	47	25–69	32–45	49	50	26–73	0.715
TP (g/dL)	15	6.9	5.3–8.7	5.4–7.1	49	7	3–10.8	0.911
WBC (cells/ $\mu$ L)	13	18,300	3,980–52,000	5,300–19,800	40	14,000	1,000–52,000	0.030*
Platelets (cells/ $\mu$ L)	11	125,000	3,160–697,000	177,000–398,000	30	257,000	30,000–512,000	0.219
Lactate (mmol/L)	13	2.4	1–10.8	0–2	29	3.1	1.1–12	0.989
Glucose (mg/dL)	13	99	47–129	65–112	30	119	54–216	0.290
BUN (mg/dL)	9	16	8–109	5–30	23	18	5–55	0.828
Creatinine (mg/dL)	3	0.6	0.5–0.6	0.7–1.8	5	1.2	0.8–3.6	0.140
Albumin g/dL	12	2.6	2–5	2.5–3.7	42	2.3	1–4.3	0.139
ALT (U/L)	12	60	11–460	16–91	44	43	14–4,029	0.732
AST (U/L)	11	101	25–1,757	23–65	31	75	29–1,413	0.829
ALP (U/L)	12	336	26–8,294	20–155	44	227	53–3,462	0.879
GGT (U/L)	11	14	5–405	7–24	44	14	5–227	0.914
Sodium (mmol/L)	13	150	130–154	140–150	30	143	130–153	0.221
Potassium (mmol/L)	13	4.2	3.7–4.8	3.9–4.9	30	4.1	3.5–4.8	0.787
Magnesium (mmol/L)	7	0.3	0.2–0.5	0.1–1.5	22	0.4	0.2–0.6	0.539

\*Value is significant ( $P < 0.05$ ).  
TP = Total protein concentration. ALT = Alanine transaminase. AST = Aspartate transaminase. ALP = Alkaline phosphatase. GGT =  $\gamma$ -Glutamyltransferase.

Table 2—Clinical laboratory data of cats with primary or secondary peritonitis.

Variable	Primary peritonitis				Secondary peritonitis			
	No. of cats	Median	Range	Reference range	No.	Median	Range	P value
PCV (%)	9	31	13–43	28–40	11	38	13–51	0.491
TP (g/dL)	9	5.4	4.2–8	6–8.6	11	8	5.8–9.8	0.001*
WBC (cells/ $\mu$ L)	9	3,300	272–31,000	4,004–18,700	10	12,000	2,900–119,000	0.142
Platelets (cells/ $\mu$ L)	9	150,000	44,400–551,000	175,000–500,000	9	212,000	45,400–543,700	0.142
Lactate (mmol/L)	8	2.9	1.1–5.8	0–2	7	5.2	1.4–6.5	0.132
Glucose (mg/dL)	7	123	18–385	67–168	4	126	93–190	0.601
BUN (mg/dL)	7	30	15–100	15–32	4	39	29–77	0.851
Creatinine (mg/dL)	2	1.2	0.9–1.4	1–2	4	1.2	0.9–3.2	0.873
Albumin (g/dL)	8	1.8	1.2–2.4	2.4–3.8	9	2.5	1.1–3	0.010*
ALT (U/L)	8	102	15–347	33–152	8	71	24–487	0.630
AST (U/L)	8	191	34–470	1–37	5	118	34–136	0.068
ALP (U/L)	8	36	19–447	22–87	8	23	10–143	0.210
GGT (U/L)	8	8	5–64	5–19	5	7	5–20	0.537
Sodium (mmol/L)	8	147	132–153	140–150	4	149	142–155	0.749
Potassium (mmol/L)	8	3.9	2.7–5.1	3.9–4.9	4	4.3	4–4.3	0.371
Magnesium (mmol/L)	7	0.5	0.4–2.1	0.1–1.5	4	0.6	0.5–0.6	0.073

See Table 1 for key.

Bacteria were detected by use of cytologic examination in 6 dogs and by positive results of bacterial culture in 9 dogs. Cocci were detected cytologically in 3 dogs (2/2 were gram positive), and bacilli were detected in 3 dogs. Bacteria of 6 genera were cultured from the peritoneal cavity, including *Enterococcus* spp ( $n = 5$  dogs), *Clostridium* spp (3), *Escherichia coli* (3), *Propriobacterium* spp (2), *Bacillus* spp (1), and *Staphylococcus* spp (1). Three organisms were cultured from 2 dogs, 2 organisms were cultured from 2 dogs, and a single organism was cultured from 5 dogs. Of the cases in which Gram staining was performed or in which a culture yielded positive results (11/15 dogs), gram-positive bacteria were found in 91% of dogs. Of the total bacteria cultured, 80% were gram-positive bacteria.

Bacteria were detected by use of cytologic examination in 4 cats and by positive results of bacterial culture

in 5 cats. A Gram stain was not performed in any cat, and the cytologic diagnoses included bacilli in 3 cases and cocci in 1 case. Three bacterial genera were cultured from the peritoneal cavity, including *E coli* ( $n = 2$  cats), *Streptococcus* spp (2), and *Clostridium* spp (1). All feline cases were monobacterial. Of the total bacteria cultured, 60% were gram-positive bacteria.

Surgery was performed in 14 animals and necropsy in 10 animals to determine whether intraperitoneal leakage had occurred. A full abdominal exploration was performed in 14 animals (9 dogs and 5 cats). No perforations of any viscus and no abscesses were detected in any animal. Generalized fibrinous adhesions were found in 4 animals, and intestinal serosal inflammation (based on visual appearance) was found in 2 animals. Liver samples from 2 of the cats treated via surgery revealed hepatic lipidosis histologically.

Necropsy was performed in 10 animals (6 dogs and 4 cats). In the dogs, lesions included nephritis (n = 4 dogs), liver congestion (3), pancreatic fat necrosis (2), splenic nodular hyperplasia (1), cystitis (1), liver infarction (1), splenic infarction (1), and bilateral pheochromocytomas (1). In the cats, lesions included enteritis (n = 2 cats), hepatopathy (1), pancreatic necrosis (1), liver capsulitis (1), liver congestion (1), splenic capsular fibrosis (1), metritis (1), hepatitis (1), and pancreatitis (1). No portosystemic shunts were detected either surgically or during necropsy.

Six dogs were euthanatized, and 2 dogs died during hospitalization. Seven dogs survived to discharge. Of those, 2 were lost to follow-up, 1 was euthanatized for an unrelated disease 75 days after diagnosis of primary peritonitis, and 4 were still alive at 565, 910, 2,675, and 3,165 days after diagnosis of primary peritonitis. Six of the 9 dogs that underwent surgery survived to discharge.

Four cats were euthanatized, and 1 cat died during hospitalization. Four cats survived to discharge. Of those, 2 died from unrelated diseases at 467 and 665 days after diagnosis of primary peritonitis and 2 were still alive at 965 and 2,157 days after diagnosis of primary peritonitis. Two of the 5 cats that underwent surgery survived to discharge.

**Secondary peritonitis**—Forty-nine dogs met inclusion criteria for secondary peritonitis. Dog breeds included mixed breed (n = 15 dogs), Golden Retriever (6), Rottweiler (6), Labrador Retriever (5), German Shepherd Dog (3), Australian Shepherd Dog (2), Schnauzer (2), Scottish Terrier (2), and 1 each of American Pit Bull Terrier, Bassett Hound, Cairn Terrier, Great Dane, Poodle, Sharpei, Shih Tzu, and West Highland White Terrier. Mean age of dogs was  $7 \pm 3.7$  years, and there were 18 sexually intact males, 14 castrated males, 11 sexually intact females, and 6 spayed females.

Eleven cats met inclusion criteria for secondary peritonitis. All cats were domestic shorthairs. Mean age of cats was  $10.7 \pm 5.1$  years, and there were 5 castrated males, 4 spayed females, and 2 sexually intact females.

The most common historical findings in dogs were vomiting (36/49), anorexia (24/49), lethargy (24/49), collapse (16/49), weight loss (16/49), and diarrhea (7/49). Physical examination findings in dogs included depressed mentation (27/49), inadequate hydration (25/49), signs of abdominal discomfort (24/49), high rectal temperature (15/49), poor nutritional condition (11/49), tachypnea (11/49), tachycardia (10/49), abdominal distention (8/49), and pale mucous membranes (8/49).

The most common historical findings in cats were anorexia (8/11), lethargy (6/11), vomiting (6/11), and weight loss (5/11). Physical examination findings in cats included inadequate hydration (8/11), high rectal temperature (6/11), poor nutritional condition (6/11), depressed mentation (5/11), abdominal distention (3/11), low rectal temperature (3/11), pale mucous membranes (3/11), tachycardia (3/11), tachypnea (3/11), and signs of abdominal discomfort (2/11).

The most common abnormalities in dogs detected via CBC included neutrophilia (13/49), leukocytosis (13/49), and leukopenia (7/49; Table 1). The most common abnormalities detected via serum biochemical

analyses included hyperlactatemia (35/49), high aspartate transaminase activity (32/49), high alkaline phosphatase activity (31/49), hyperglycemia (27/49), high BUN concentration (15/49), and high alanine transaminase activity (12/49).

The most common abnormalities detected via CBC in cats included anemia (5/11), leukocytosis (4/11), neutrophilia (4/11), and leukopenia (1/11). The most common abnormalities detected via serum biochemical analyses included hyperlactatemia (9/11), high aspartate transaminase activity (8/11), high BUN concentration (7/11), hypoalbuminemia (3/11), hyperglycemia (2/11), high alanine transaminase activity (2/11), and high alkaline phosphatase activity (2/11). One cat was tested for FeLV and FIV, and results were negative.

The peritoneal effusion was characterized in 22 dogs and classified as an exudate in 20 dogs and a transudate in 2 dogs. The peritoneal effusion median nucleated cell count was 31,700 cells/ $\mu$ L (range, 800 to 159,000 cells/ $\mu$ L), and the mean total protein concentration of the effusion was  $3.52 \pm 1$  g/dL. The peritoneal effusion was not characterized in any of the feline cases.

Bacteria were detected via cytologic examination in 15 dogs and via positive results of bacterial culture in 34 dogs. Use of cytologic examination identified intracellular bacilli in 8 dogs and intracellular cocci in 7 dogs. Eleven bacterial genuses were cultured from the peritoneal cavity, including *E coli* (n = 21 dogs), *Enterococcus* spp (14), *Clostridium* spp (9), *Streptococcus* spp (5), *Staphylococcus* spp (4), *Paraeruginosa* spp (2), *Proteus* spp (2), *Acinetobacter* spp (1), *Bacteroides* spp (1), *Enterobacter* spp (1), and *Serratia* spp (1). Four organisms were cultured from 1 dog, 3 organisms were cultured from 3 dogs, 2 organisms were cultured from 18 dogs, and a single organism was cultured from 12 dogs. Of the total bacteria cultured, 52% were gram-positive bacteria.

Bacteria were detected via cytologic examination in 2 cats and via positive results of bacterial culture in 9 cats. Cytologic examination detected intracellular bacilli in both cats.

Three bacteria genuses were cultured from the peritoneal cavity of cats, including *E coli* (n = 5 cats), *Clostridium* spp (4), and *Streptococcus* spp (2). Two organisms were cultured from 2 cats, and a single organism was cultured from 7 cats. Of the total bacteria cultured, 6 of 11 were gram-positive bacteria.

A full abdominal exploration was performed in 53 animals (42 dogs and 11 cats). The surgical procedures performed included intestinal resection and anastomosis (n = 21 animals), partial gastric or intestinal resection of perforated ulcers (9), ovariohysterectomy (7), liver lobectomy (4), cholecystectomy (2), bladder rupture repair (2), lymph node debriement (1), nephrectomy (1), and bite-wound repair (1). In 2 animals, only biopsies were performed, and 3 animals were euthanatized during surgery.

In the canine cases, the sources of intraperitoneal leakage included gastrointestinal perforation (n = 15 dogs), dehiscence of a previous enterotomy or gastrointestinal resection and anastomosis site (6), pyometra and uterine rupture (6), liver abscess (5), ruptured gastrointestinal neoplasm (4), prostatic abscess (4), trauma (2), pancreatic abscess (2), gallbladder rupture

(2), cecal abscess (1), ureteral leakage (1), and urinary bladder leakage after cystotomy (1). In the feline cases, the sources of intraperitoneal leakage included ruptured gastrointestinal neoplasm (n = 4 cats), pyometra and uterine rupture (2), intra-abdominal bite wounds (1), mesenteric lymph node abscess (1), ruptured cecal abscess (1), urinary bladder leakage after cystotomy (1), and gastrointestinal tract perforation (1).

Twelve dogs were euthanatized, and 3 dogs died during hospitalization. Thirty-four dogs were discharged from the hospital. The only follow-up in 8 dogs was a suture removal appointment, and in 11 other dogs, the final status of the dog was unknown. Of the remaining 15 dogs, the known survival times ranged from 30 to 1,900 days with a median of 135 days. Thirty-four of the 42 dogs that underwent surgery survived to discharge.

Five cats were euthanatized, and 2 cats died during hospitalization. Four cats were discharged from the hospital. Of those, 2 were lost to follow-up, 1 returned for suture removal 20 days after surgery, and 1 cat was returned 71 days after discharge for recheck examination. Four of the 11 cats that underwent surgery survived to discharge.

Substantial differences between cases of primary and secondary peritonitis were detected in several categories, including historical findings, physical examination findings, clinical laboratory findings, bacteriologic results, effusion characteristics, and outcome (Tables 1–3). Significantly more dogs with primary peritonitis had a his-

tory of diarrhea than did dogs with secondary peritonitis. Significantly more dogs and cats with primary peritonitis had tachypnea, compared with animals with secondary peritonitis. Additionally, significantly more cats with primary peritonitis had signs of pain on abdominal palpation. Significantly more dogs with primary peritonitis had leukocytosis, compared with dogs with secondary peritonitis. Significantly more cats with primary peritonitis had hypoproteinemia and hypoalbuminemia than did cats with secondary peritonitis. In dogs, a greater proportion of primary peritonitis cases were associated with gram-positive infections versus gram-negative infections. Dogs with secondary peritonitis had significantly more diagnoses of an exudate than did dogs with primary peritonitis. Significantly more dogs with secondary peritonitis in which surgery was performed were discharged than were dogs with primary peritonitis that underwent surgery.

## Discussion

The pathogenesis of primary peritonitis in humans is still not fully understood. Primary peritonitis is thought to arise from hematogenous or lymphogenous bacterial spread, transmural bacterial migration from the gastrointestinal tract, or bacterial passage from the fallopian tubes; however, support for these theories is lacking.<sup>1,2,16</sup> Disease processes that predispose humans to primary peritonitis include ascites, liver disease, and portosystemic shunting. These 3 conditions are often diagnosed concurrently, most commonly with liver cirrhosis.<sup>16–18</sup>

Support for these theories among the dog and cat population of the present study was not found in many instances. In sexually intact female dogs, a direct communication between the peritoneal cavity and ovarian bursa exists during ovulation, and spread of an infectious agent by this route should be considered.<sup>19</sup> However, only 2 of the 24 primary peritonitis cases were diagnosed in sexually intact females, and primary peritonitis was not found more frequently in sexually intact females than was secondary peritonitis. In none of the animals were blood cultures performed, and none had clinically apparent preexisting gastrointestinal tract disease, making conclusions about pathogenesis difficult. Two cats with primary peritonitis had hepatic lipidosis, but the time of onset of hepatic lipidosis could not be determined retrospectively. No animals in this report had portosystemic shunting or a history of known ascites prior to the diagnosis of septic peritonitis. Additionally, ascites as a result of diseases in the liver and heart was not noted. In the veterinary literature, 3 clinical reports<sup>13–15</sup> provide descriptions of potential cases of primary peritonitis. In those cases, an exact cause of the primary peritonitis could not be identified, and therefore, further comparison with the cases of the present study is not possible.

In the dogs reported here, the ages at which cases of primary and secondary peritonitis were diagnosed were similar (6.4 and 7 years, respectively), and those ages were similar to those reported in a study<sup>20</sup> evaluating secondary peritonitis in dogs. Although the mean ages of cats with primary and secondary peritonitis in our study differed by approximately 3 years, this difference was not significant.

Table 3—The *P* values for the comparison of variables of primary versus secondary peritonitis in dogs and cats.

Variable	<i>P</i> value	
	Dogs	Cats
Signalment		
Age	0.476	0.178
Sex	0.861	0.835
Historical findings		
Anorexia	0.459	1.000
Diarrhea	0.019*	—
Lethargy	0.290	0.062
Vomiting	0.310	1.000
Physical examination findings		
Signs of abdominal discomfort	0.097	0.023*
Abdominal distention	0.152	0.179
Depressed mentation	0.114	0.615
Hyperthermia	0.061	0.106
Hypothermia	0.489	0.358
Inadequate hydration	0.831	0.550
Poor nutritional condition	0.195	0.302
Tachycardia	0.156	0.175
Tachypnea	< 0.001*	< 0.001*
Bacteriologic evaluation		
Gram-positive infection	0.037*	0.238
Monobacterial population	0.461	0.505
Effusion characteristics		
Exudate	0.020*	—
Total nucleated cell count	0.067	—
TP	0.369	—
Outcome		
Discharge (animal received surgery)	0.013*	1.000
Discharge (all animals)	0.066	0.642

— = Not applicable.  
See Table 1 for remainder of key.

Dogs and cats with primary and secondary peritonitis were evaluated most commonly after owners reported nonspecific historical findings such as lethargy, vomiting, and anorexia. A history of diarrhea was more commonly reported in dogs with primary peritonitis. A possible explanation for this finding might be that underlying gastrointestinal tract disease was present for longer than known by the owner in the dogs with primary peritonitis, and it should be considered that bacterial translocation may occur because of gastrointestinal tract disease. Retrospectively, it was not possible to determine whether the cases of diarrhea were more consistent with origin in the large or small intestine, and further theorization about bacterial load or particular diseases cannot be made.

Physical examination findings for dogs and cats were consistent with shock and inadequate hydration. Approximately one-third of dogs and cats with secondary peritonitis were reported to have weight loss by their owners—a finding not detected in animals with primary peritonitis. This may be attributable to the insidious nature of some of the secondary peritonitis disease processes, such as gastrointestinal tract neoplasia or organ abscesses. These diseases can often result in weight loss over an extended period because owners may not detect a change in their pet until the severe signs associated with secondary peritonitis have appeared. Dogs and cats with primary peritonitis were more likely to have tachypnea. Again, retrospectively, it is impossible to comment on the reason for this finding because these cases may have been caused by non-respiratory tract causes, such as stress or thoracic cavity compression secondary to voluminous peritoneal effusion.

Abdominal discomfort is often an early indicator of primary peritonitis in humans.<sup>1,2</sup> Seventy-three percent of dogs and 78% of cats with primary peritonitis had signs of abdominal discomfort, compared with 49% of dogs and 20% of cats in the secondary peritonitis group. This frequency of diagnosis in the secondary peritonitis group was similar to that reported in dogs (53%) but varies substantially from what has been reported in cats (62%).<sup>21,22</sup> Additionally, signs of abdominal discomfort were found more commonly in cats with primary peritonitis than in cats with secondary peritonitis. Abdominal distention was recorded in cats with primary peritonitis twice as often as in dogs with primary peritonitis. Abdominal distention detected by owners or during physical examination has been reported to be a common finding in cats with peritoneal effusion.<sup>23</sup>

Protein loss resulting in hypoproteinemia and hypoalbuminemia is common in cats with secondary peritonitis.<sup>21</sup> However, the cats with primary peritonitis in the present study more commonly had hypoproteinemia and hypoalbuminemia than did cats with secondary peritonitis. On the basis of this finding, perhaps further consideration should be given to the theory that an underlying clinically undiagnosed gastrointestinal tract disease resulted in primary peritonitis and may also have caused protein loss into the gastrointestinal tract.<sup>24</sup>

Comparisons between septic and nonseptic effusions in dogs and cats have been reported.<sup>25</sup> The nucleated cell count of septic effusions in cases of secondary peritonitis is greater than that in nonseptic effusions.<sup>25</sup>

In the primary peritonitis cases of the present study, the median WBC count of the peritoneal effusion was approximately 7,000 cells/ $\mu$ L in dogs and 3,000 cells/ $\mu$ L in cats. The median nucleated cell counts of the effusion in the animals of this report were closer to nonseptic effusions in dogs and cats of the study by Bonczynski et al.<sup>25</sup> However, in a comparison of the cases of primary and secondary peritonitis in the dogs of the present study, the peritoneal fluid WBC counts were not significantly different.

Secondary septic peritonitis is considered to be an exudative process caused by protein loss from increased vascular permeability and massive cellular influx into the peritoneal cavity. The majority (67%) of primary peritonitis cases were diagnosed with an exudative effusion, and the affected dogs and cats likely had a similar inflammatory condition as those with secondary peritonitis. Alterations in WBC count and protein concentrations should be expected. However, in 7 of 21 of the primary peritonitis cases with peritoneal fluid analysis, the fluid was characterized as either a transudate or a modified transudate. Furthermore, in canine cases of secondary peritonitis, an exudate was significantly more common than in primary peritonitis. This may indicate that the disease process differs between primary and secondary peritonitis. Another consideration is that the bacteria detected may be contaminants. If appropriate sterile technique is not followed during abdominocentesis or plating of culture media, a false-positive result may occur.

In an early study,<sup>16</sup> the most commonly cultured bacteria from human cases of primary peritonitis were gram-negative bacteria that accounted for 69% of positive culture results. However, results of a more recent study<sup>26</sup> suggested that gram-positive bacteria are more commonly cultured from cases of primary peritonitis. Theories regarding this finding include the increased frequency of quinolone administration in patients at risk for developing primary peritonitis and increased frequency of invasive procedures, indwelling catheters, and hospitalizations.<sup>26</sup>

Gram-positive bacteria were the most commonly cultured organisms in the primary peritonitis patients of the study reported here. Of the 16 cases in which Gram staining was performed, 80% of bacteria cultured in dogs and 60% of bacteria cultured in cats were gram positive. This varied from reports<sup>12,25</sup> of secondary peritonitis in companion animals because gram-negative bacteria are cultured more commonly. Among the cases of the present study, gram-negative bacteria were significantly more common in secondary peritonitis cases as well.

In human primary peritonitis cases, *E coli* is the bacteria most often cultured from the peritoneal cavity.<sup>1,16,26</sup> Other common bacteria cultured in human cases include *Klebsiella* spp, *Streptococcus* spp, and *Enterococcus* spp.<sup>2</sup> Similarly, in the primary and secondary peritonitis cases of the present study, the predominating bacteria cultured from the peritoneal cavity are regularly found in the gastrointestinal tract. Most of the canine cases consisted of infections with *E coli*, *Enterococcus* spp, and *Clostridium* spp, and the same 3 bacteria (*Clostridium* spp, *E coli*, and *Streptococcus* spp) were cultured from cats in the primary and second-

ary peritonitis cases. *Streptococcus* spp, *Paraeruginosa* spp, *Proteus* spp, *Acinetobacter* spp, *Bacteroides* spp, *Enterobacter* spp, and *Serratia* spp were cultured from the peritoneal cavity of dogs with secondary peritonitis but not in dogs with primary peritonitis and vice versa for *Propriobacterium* spp and *Bacillus* spp. These bacteria were found in few of the cases, yet many are often found within the gastrointestinal tract as well. As stated, bacterial translocation across the gastrointestinal tract is theorized to play a role in the development of primary peritonitis. Retrospectively, it is difficult to determine whether the animals with primary peritonitis in the present study had a reason for a compromised gastrointestinal mucosal barrier potentially leading to bacterial translocation; however, none had a history of preexisting gastrointestinal tract disease prior to being evaluated for primary peritonitis.

Previous studies<sup>11,12,21</sup> reveal that cases of secondary peritonitis in companion animals are often polybacterial. In contrast, cases of primary peritonitis recorded in humans are usually monobacterial.<sup>18</sup> This was similar in our primary peritonitis cases as well, with 56% of canine cases and 100% of feline cases being monobacterial. Additionally, 78% of the cultures of cats in the secondary peritonitis group were monobacterial, which differed from a previous report.<sup>21</sup> Statistical analysis, however, did not reveal a difference between primary and secondary peritonitis with regard to monobacterial or polybacterial infections.

Reported survival rate in cases of secondary peritonitis in veterinary medicine is variable and often depends on other factors, such as the cause of secondary peritonitis and the drainage technique used. Survival rates of 32% to 54% have been reported in cases of secondary peritonitis in dogs,<sup>6,20,27</sup> which is similar to the 47% survival rate reported in the present study. Our survival rate in cats of 44%, however, was much lower than the 70% survival rate that was reported in 1 study<sup>21</sup> evaluating cats with septic peritonitis. No difference was detected in survival rates when the primary and secondary peritonitis cases of this study were compared. However, it should be mentioned that dogs undergoing surgery for primary peritonitis were less likely to survive to discharge than those undergoing surgery for secondary peritonitis. For humans with primary peritonitis, surgery is not recommended because it may result in worsening of an underlying disease process and subsequently increase morbidity.<sup>10,16</sup>

Several limitations of this study are obvious. First, to fulfill the inclusion criteria for primary peritonitis cases, there was a reliance on the thoroughness of those conducting the necropsy or performing the abdominal exploration. Poor technique during either of those procedures could result in a false-positive diagnosis of primary peritonitis with a subsequent false-negative diagnosis of secondary peritonitis. Second, it cannot be assumed that the disease processes in humans and companion animals are identical. In addition, an association between disease processes such as cirrhosis and portosystemic shunting could not be detected because animals included in the study did not have those conditions. Other limitations included low peritonitis case numbers in both dogs and cats and the reliance on

retrospective medical record review for data recording. Finally, the comparison between cases of primary and secondary peritonitis could be improved with a greater number of cases. Greater numbers may reveal significant differences in some of the other comparisons.

Animals with primary and secondary peritonitis had similar historical and physical examination findings, but the frequency of those findings may differ between these 2 forms of peritonitis. Furthermore, dogs with primary peritonitis more commonly had diarrhea, and cats with primary peritonitis more often had signs of abdominal discomfort than those with secondary peritonitis. The percentage of animals with primary peritonitis with a peritoneal transudative effusion was higher than that of those with secondary peritonitis, and dogs with secondary peritonitis developed an exudative effusion significantly more commonly than did those with primary peritonitis. Gram-positive bacteria in the peritoneal effusion predominated among the animals with primary peritonitis, and animals with secondary peritonitis had significantly more gram-negative infections. No difference in outcome was detected between animals with primary versus secondary peritonitis; however, dogs with secondary peritonitis that underwent surgery were more commonly discharged than were those dogs that underwent surgery for primary peritonitis.

Further research into the pathogenesis and treatment of this disease process is necessary. Prospective studies with larger case numbers are needed before recommendations about treating with antimicrobials alone and the avoidance of surgery can be made.

a. Stata, version 8.0 for Windows, Stata Corp, College Station, Tex.

## References

1. Johnson CC, Baldessarre J, Levison ME. Peritonitis: update on pathophysiology, clinical manifestations, and management. *Clin Infect Dis* 1997;24:1035–1047.
2. Laroche M, Harding G. Primary and secondary peritonitis: an update. *Eur J Clin Microbiol Infect Dis* 1998;17:542–550.
3. Malangoni MA. Evaluation and management of tertiary peritonitis. *Am Surg* 2000;66:157–161.
4. Evans HL, Raymond DP, Pelletier SJ, et al. Diagnosis of intra-abdominal infection in the critically ill patient. *Curr Opin Crit Care* 2001;7:117–121.
5. Jarvis J, Trivedi S, Sheda S, et al. Primary peritonitis in adults: is it time to look for a better diagnostic classification? *ANZ J Surg* 2006;76:127–129.
6. Woolfson JM, Dulisch ML. Open abdominal drainage in the treatment of generalized peritonitis in 25 dogs and cats. *Vet Surg* 1986;15:27–32.
7. Greenfield CL, Walshaw R. Open peritoneal drainage for treatment of contaminated peritoneal cavity and septic peritonitis in dogs and cats: 24 cases (1980–1986). *J Am Vet Med Assoc* 1987;191:100–105.
8. Swann H, Hughes D. Diagnosis and management of peritonitis. *Vet Clin North Am Small Anim Pract* 2000;30:603–615.
9. Quenzer RW. Primary peritonitis: spontaneous bacterial peritonitis. *Curr Treat Options Infect Dis* 2001;3:359–365.
10. Rimola A, Garcia-Tsao G, Navas M, et al. Diagnosis, treatment and prophylaxis of spontaneous bacterial peritonitis: a consensus document. *J Hepatol* 2000;32:142–153.
11. Seim HB. Management of peritonitis. In: Bonagura JD, Kirk RW, eds. *Current veterinary therapy XII: small animal practice*. Philadelphia: WB Saunders Co, 1995;933–937.
12. Kirby BM. Peritoneum and peritoneal cavity. In: Slatter D, ed.

- Textbook of small animal surgery*. 3rd ed. Philadelphia: WB Saunders Co, 2003;414–445.
13. Ingham B, Brentnall DW. Acute peritonitis in a kitten associated with *Salmonella typhimurium* infection. *J Small Anim Pract* 1972;13:71–74.
  14. Dickie CW, Sniff ES. Chlamydia infection associated with peritonitis in a cat. *J Am Vet Med Assoc* 1980;176:1256–1259.
  15. Clark DM, Harvey HJ, Roth L, et al. Clostridial peritonitis associated with a mast cell tumor in a dog. *J Am Vet Med Assoc* 1986;188:188–190.
  16. Wilcox CM, Dismukes WE. Spontaneous bacterial peritonitis. A review of pathogenesis, diagnosis, and treatment. *Medicine (Baltimore)* 1987;66:447–456.
  17. Evans LT, Kim WR, Poterucha JJ, et al. Spontaneous bacterial peritonitis in asymptomatic outpatients with cirrhotic ascites. *Hepatology* 2003;37:897–901.
  18. Boixeda D, De Luis DA, Aller R, et al. Spontaneous bacterial peritonitis. Clinical and microbiological study of 233 episodes. *J Clin Gastroenterol* 1996;23:275–279.
  19. Van Israel N, Kirby BM, Munro EAC. Septic peritonitis secondary to unilateral pyometra and ovarian bursal abscessation in a dog. *J Small Anim Pract* 2002;43:452–455.
  20. Lanz OI, Ellison GW, Bellah JR, et al. Surgical treatment of septic peritonitis without abdominal drainage in 28 dogs. *J Am Anim Hosp Assoc* 2001;37:87–92.
  21. Costello MF, Drobatz KJ, Aronson LR, et al. Underlying cause, pathophysiologic abnormalities, and response to treatment in cats with septic peritonitis: 51 cases (1990–2001). *J Am Vet Med Assoc* 2004;225:897–902.
  22. Mueller MG, Ludwig LL, Barton LJ. Use of closed-suction drains to treat generalized peritonitis in dogs and cats: 40 cases (1997–1999). *J Am Vet Med Assoc* 2001;219:789–794.
  23. Wright KN, Gompf RE, DeNovo RC Jr. Peritoneal effusion in cats: 65 cases (1981–1997). *J Am Vet Med Assoc* 1999;214:375–381.
  24. Peterson PB, Willard MD. Protein-losing enteropathies. *Vet Clin Small Anim Pract* 2003;33:1061–1082.
  25. Bonczynski JJ, Ludwig LL, Barton LJ, et al. Comparison of peritoneal fluid and peripheral blood pH, bicarbonate, glucose, and lactate concentration as a diagnostic tool for septic peritonitis in dogs and cats. *Vet Surg* 2003;32:161–166.
  26. Cholongitas E, Papatheodoridis GV, Lahanas A, et al. Increasing frequency of gram-positive bacteria in spontaneous bacterial peritonitis. *Liver Int* 2005;25:57–61.
  27. Hosgood G, Salisbury SK. Generalized peritonitis in dogs: 50 cases (1975–1986). *J Am Vet Med Assoc* 1988;193:1448–1450.