

Pancreatic Abscess in 36 Dogs: A Retrospective Analysis of Prognostic Indicators

Thirty-six dogs were diagnosed with pancreatic abscess by the presence of purulent exudate within the parenchyma of the pancreas during exploratory laparotomy. Data regarding history, physical examination findings, clinicopathological data, diagnostic imaging findings, bacteriological culture results, abdominal drainage technique, and perioperative treatment were evaluated for factors predictive of survival. Elevated blood urea nitrogen, serum alkaline phosphatase activity, and rising bicarbonate ion concentration were each found to have statistically significant ($P<0.05$) influences on survival to discharge. Twenty-two (71%) of 36 dogs died or were euthanized prior to discharge from the hospital. **J Am Anim Hosp Assoc 2008;44:171-179.**

Jonathan R. Anderson, DVM

Karen K. Cornell, DVM, PhD,
Diplomate ACVS

Nolie K. Parnell, DVM,
Diplomate ACVIM

S. Kathleen Salisbury, DVM, MS,
Diplomate ACVS

RS

From the Department of Small
Animal Medicine and Surgery
(Anderson, Cornell),
Veterinary Teaching Hospital,
College of Veterinary Medicine,
The University of Georgia,
502 D.W. Brooks Drive,
Athens, Georgia 30602
and the Department of Veterinary
Clinical Sciences (Parnell, Salisbury),
School of Veterinary Medicine,
Purdue University,
625 Harrison Street,
West Lafayette, Indiana 47907.

Doctor Anderson's current address is
Pittsburgh Veterinary Specialists,
882 Butler Street,
Pittsburgh, Pennsylvania 15237.

Introduction

Pancreatic abscesses are infrequently reported, with only 37 total cases reported in four separate references in the current veterinary literature.¹⁻⁴ Mortality rates range from 50% to 86% in these previous reports. Many authors suggest pancreatic abscesses develop as a sequela to pancreatitis in dogs.¹⁻⁴ In two retrospective reports of pancreatitis, pancreatic abscesses occurred in one (1.4%) of 72 cases and in nine (6.5%) of 139 cases.^{2,4} In a study of 70 dogs submitted for necropsy after dying or having been euthanized due to acute pancreatitis, only three had acute suppurative pancreatitis, and there was no specific comment or gross description of the presence of phlegmon or abscess formation.⁵

The terminology used to describe inflammatory masses of the pancreas is complex and unclear.^{2,6,7} Previous reports have defined a pancreatic abscess based on gross findings of mucopurulent, necrotic exudates within the pancreatic parenchyma, with or without extension into adjacent tissues.^{1,3,6,7} Others argue that an abscess is by definition a septic collection of the exudates described above, but they concede that surgical exploration and debridement are warranted regardless of the bacteriological status.^{2,7}

Coleman reported an important difference between canine and human pancreatic abscesses: the isolation of microbial agents is much less frequent in canine cases.⁶ Reported histopathological findings of pancreatic abscesses are necrotizing pancreatitis and chronic-active pancreatitis.^{1,2,6} With the limited number of cases reported, limited information is available regarding pre- and perioperative prognostic factors for pancreatic abscesses.

Regarding canine pancreatitis, Ruaux and Atwell developed a Pancreatitis Severity Score (PSS) in an attempt to determine likelihood of mortality associated with pancreatitis based on initial clinicopathological findings.⁸ They reported that pancreatic enzyme activities were inaccurate in predicting mortality, but a significant interaction was demonstrated between number of organ systems exhibiting dysfunction (used to establish the PSS) and mortality.⁸ Recently, this PSS was investigated retrospectively in a group of 15 dogs with pancreatic abscess.³ The PSS did not significantly influence outcome; however, not all variables used in

the original PSS index were available to the investigators. In that study, Johnson and Mann reported a shorter hospitalization time and better survival outcome with omentalization of pancreatic abscesses versus open peritoneal drainage, but the difference was not statistically significant.³

The purposes of this study were to evaluate the history, physical examination findings, clinicopathological data, diagnostic imaging findings, bacteriological culture results, abdominal drainage technique, and the effects of perioperative treatment on survival in dogs treated for pancreatic abscess, as well as to determine if any of these factors had a significant influence on outcome. For the purposes of this study, a pancreatic abscess was defined as purulent exudate within the pancreatic parenchyma, grossly identified at the time of exploratory laparotomy.

Materials and Methods

Inclusion Criteria

A search of the medical records of the College of Veterinary Medicine at The University of Georgia and the School of Veterinary Medicine at Purdue University was conducted. Dogs were identified that were diagnosed between 1988 and 1998 with pancreatic abscess, based on the identification of purulent exudates within the pancreatic parenchyma during exploratory laparotomy. Dogs with pancreatic neoplasia confirmed by histopathological analysis were excluded. Thirty-six cases met these criteria; 22 were from The University of Georgia, and 14 were from Purdue University. Medical records were reviewed, and data were recorded.

Data included the following: breed; age; initial clinical signs and duration; pre- and postoperative temperatures; results of complete blood count (CBC) and serum biochemical profiles at presentation; results of CBC and serum biochemical profiles within the 7-day postoperative period; pre- and postoperative PSS (defined below); the type of abdominal drainage (if used); administration of antibiotics prior to hospitalization; administration of heparin and duration of heparin administration; administration of colloid support and duration of colloid support; administration of plasma; administration of nutritional support; result of coagulation testing (when performed); results of bacteriological cultures obtained at surgery; and surgical exploration prior to referral.

Thoracic radiography reports were evaluated for the presence of interstitial, bronchial, or alveolar disease; pleural effusion; pulmonary edema; microcardia; cardiomegaly; or a combination of the above. Abdominal radiography reports were evaluated for decreased serosal detail in the cranial abdomen; evidence of peritoneal effusion; a mass effect at the area of the pancreas; or a combination of the above. Abdominal ultrasonography reports were evaluated for abnormal echogenicity of the pancreas; a mass at or near the pancreas; a mass unrelated to the pancreas; any hypo-echoic or anechoic cavity near the pancreas; or free peritoneal fluid.

Blood values came from two different laboratories. Each value was classified as normal or abnormal using the reference ranges of the respective laboratory. The PSS system

was assessed for its relevance in predicting outcomes of pancreatic abscesses. The system evaluates the severity of disease based on the following criteria: white blood cells (WBCs) $>24 \times 10^3$ cells/ μ L; renal dysfunction (blood urea nitrogen [BUN] >40 mg/dL or serum creatinine >3.4 mg/dL); elevated hepatic enzyme activities (alkaline phosphatase [ALP], alanine aminotransferase [ALT], or aspartate transaminase [AST] exceeding three times the upper limit of the given reference range); acid-base abnormalities (serum bicarbonate <13 or >26 mmol/L); and endocrine pancreas dysfunction (blood glucose concentration >234 mg/dL or β -hydroxybutyrate concentration >1 mmol/L).⁸ The β -hydroxybutyrate concentration was not measured in any of the cases; blood glucose was used to determine whether endocrine pancreatic dysfunction should be included in the PSS.

Fourteen cases had total carbon dioxide (TCO₂) measured in the place of bicarbonate ion concentration; in these 14 cases, TCO₂ was used in place of bicarbonate ion concentration in order to calculate the PSS. When all variables were available for a case, the pre- and postoperative PSSs were calculated, and their influence on outcome was investigated. For the 14 cases mentioned above, TCO₂ was also substituted for bicarbonate ion concentration when bicarbonate was evaluated as a predictor of outcome. Outcome was defined as successful if dogs survived to be discharged from the hospital. For surviving dogs, their owners were contacted by phone or at the time of recheck evaluations for follow-up information.

Statistical Analyses

A logistic model was used to analyze the probability of survival to discharge, dependent on clinical and blood parameters. Each parameter was entered into the model separately. Maximum likelihood estimates and corresponding Wald statistics, as well as odds-ratios, were calculated for each parameter to determine if there was a relationship with survival to discharge probability. In addition, some subsets of parameters that were likely to be correlated were entered into the model as a group. Groupings were as follows: serum ALT and ALP activities together; serum amylase and lipase activities together; and coagulation parameters (i.e., prothrombin time [PT], thrombin time [TT], activated partial thromboplastin time [APTT], and activated clotting time) together with platelet counts. All analyses were performed using Statistical Analysis Software, Version 9.1.^a

Results

Signalment

Thirty-six dogs met the criteria for inclusion. Twenty-one were female (20 spayed), and 15 were male (six castrated). Age ranged from 0.4 to 14 years (mean 7.2 ± 3.8 years). Weights ranged from 1.3 to 49 kg (mean 16.2 ± 13.3 kg). Affected breeds are listed in Table 1.

History

Presenting complaints included vomiting (n=33), anorexia (n=17), lethargy (n=13), diarrhea (n=13), polyuria and

Table 1**Breeds Represented**

Mixed-breed dog	9
Miniature schnauzer	6
Cocker spaniel	2
Labrador retriever	2
Shih tzu	2
Yorkshire terrier	2
Akita	1
Basset hound	1
Beagle	1
Boston terrier	1
Chow chow	1
Dachshund	1
Doberman pinscher	1
Finnish spitz	1
Fox terrier	1
Lhasa apso	1
Miniature poodle	1
Pomeranian	1
West Highland white terrier	1

Table 2**Clinical Signs at Presentation**

Clinical Sign	No. of Dogs (%)
Vomiting	33 (92)
Pain	21 (58)
Anorexia	17 (47)
Lethargy	13 (36)
Diarrhea	13 (36)
Palpable mass	7 (19)
Distended abdomen	6 (17)
Tachypnea or dyspnea	6 (17)
Polyuria/polydipsia	4 (11)
Icterus	3 (8)
Neurological signs	2 (6)
Melena	2 (6)
Weight loss	1 (3)
Weakness	1 (3)
Alopecia	1 (3)
Cyanosis	1 (3)
Exercise intolerance	1 (3)

polydipsia (n=4), melena (n=2), neurological signs (two cases had a 1-month history of seizures), and exercise intolerance (n=1). Twelve dogs experienced prior episodes of vomiting. Three dogs experienced trauma within 1 week prior to admission (two were hit by cars, and one was attacked by another dog). Three dogs had surgery within 1 week prior to admission (one for abdominal hernias secondary to dog bites; one for pyloric outflow obstruction; and one for pancreatic debridement by the referring veterinarian). Duration of clinical signs ranged from 1 to 1095 days (59±193 days).

Concurrent diseases included diabetes mellitus (n=3), seizure disorders (n=3; two were being treated with phenobarbital), and heart murmurs (n=3; two were being treated with enalapril). Nine dogs had received steroids prior to admission, and 24 had received antibiotics. Type and duration of antibiotic therapy varied greatly, with no correlation to outcome.

Physical Examination Findings

The clinical signs at the time of presentation are listed in Table 2. The rectal temperature at presentation ranged from

99.6° to 104.8°F, with a mean of 102.5°±1.2°F. Pain during abdominal palpation was recorded in 21 dogs. A palpable abdominal mass was noted in seven dogs. Three dogs were icteric, six had a distended abdomen, and six had abnormal lung sounds auscultated. Other signs (in one dog each) included cyanosis, tachypnea, alopecia, and generalized weakness. No physical examination parameter had a significant influence on outcome.

Clinical Pathological Data

Clinicopathological findings are summarized in Tables 3 and 4. Routine hematological evaluation was performed for each of the 36 dogs on initial presentation. Results revealed anemia (n=9), thrombocytopenia (n=10), leukocytosis (n=25), and leukopenia (n=3). Twenty-two dogs had elevated neutrophil counts. Twenty-seven dogs had elevated band neutrophil counts relative to the laboratory reference ranges; in 15 dogs, the band count was ≥10% of the mature neutrophil count. Leukogram results did not influence outcome in these dogs. Total WBC count, segmented neutrophil count, band count, and band:segmented neutrophil ratio all had no significant influence on outcome.

Table 3
Results of Hematological Tests

Test	No. of Dogs Tested	No. of Dogs (%) Below Reference	No. of Dogs (%) Within Reference	No. of Dogs (%) Above Reference	Range	Reference Range
Platelets* (10 ⁶ /μL)	26	10 (38)	16 (44)	0	31-726	200-900
HCT†	36	9 (25)	27 (75)	0	9.1-55	35-55
WBC‡ (10 ⁶ /μL)	36	3 (8)	8 (22)	28 (78)	3.6-78	5.1-17
Neutrophils (10 ⁶ /μL)	36	0	14 (39)	22 (61)	0.8-62	2.9-12
Band neutrophils (10 ⁶ /μL)	36	0	9 (25)	27 (75)	0-15	0-0.45

* Ten dogs had estimated platelet counts. Three of these were decreased estimates; the remainder were adequate estimates.

† HCT=hematocrit

‡ WBC=white blood cells

Biochemical analysis at the time of initial presentation revealed four dogs to be hypoproteinemic; two of those dogs and a third with a normal total protein concentration were hypoalbuminemic. Seven dogs were hyperglycemic, and six were hypoglycemic. Six dogs had elevated BUN concentrations, three of which had elevated creatinine concentrations. Twenty dogs were hypocalcemic; ionized calcium concentrations were not available for analysis. The calcium concentrations in the three dogs with hypoalbuminemia were corrected to normal values using the following equation: adjusted calcium concentration (mg/dL) = calcium concentration (mg/dL) – albumin concentration (g/dL) + 3.5.⁹

Twenty-two of the 36 dogs had bicarbonate ion concentrations measured; they were decreased in three and elevated in one. Total carbon dioxide was measured in the other 14 of the 36 dogs; eight of them had elevated TCO₂ concentrations. Alanine aminotransferase was elevated in 15 cases and was greater than three times the upper reference limit in six cases. Alkaline phosphatase was elevated in 30 cases and was greater than three times the upper reference limit in 19 cases. Amylase blood activity was documented in 27 cases; 17 cases were hyperamylasemic. Serum lipase activity was documented in 23 cases; 12 cases exhibited hyperlipasemia. Serum total bilirubin concentration was recorded in 20 cases; hyperbilirubinemia was present in 10 cases.

The only clinicopathological measurements that showed significant influence on outcome were ALP, BUN, and

bicarbonate ion concentration. Dogs with an elevated ALP were 11.7 times more likely to die or be euthanized (confidence interval [CI] 1.18 to 114.6; $P=0.035$) than dogs with ALP activities within the reference range of the respective laboratories. The actual serum ALP activity of each case did not have a significant influence on outcome ($P=0.39$). Dogs with elevated BUN concentrations were 15.6 times more likely to die or be euthanized (CI 1.73 to 140.82; $P=0.014$) than dogs with BUN concentrations falling within the reference range of the respective laboratories. Bicarbonate ion concentration also significantly influenced outcome. For each unit rise in bicarbonate ion, dogs were 0.768 times as likely to survive to discharge from the hospital (CI 0.636 to 0.927; $P=0.0060$). Stated another way, with each unit rise (mmol/L) in bicarbonate ion, regardless of the normal reference range, dogs were 1.3 times more likely to die. However, a bicarbonate ion concentration falling within the reference limit of the respective laboratory did not influence survival (odds ratio [OR] 3.06; CI 0.663 to 14.08; $P=0.15$).

Neither serum lipase nor serum amylase activities had a significant influence on outcome. A normal serum lipase activity compared to abnormal activity yielded an OR of 4.17 for survival (CI 0.61 to 28.62; $P=0.15$), and a normal serum amylase activity compared to abnormal activity yielded an OR of 2.93 (CI 0.469 to 18.33; $P=0.25$).

Preoperative albumin concentration had no influence on outcome whether analyzed as a binary (normal or abnormal) or continuous variable. Postoperative albumin concentrations

Table 4
Results of Biochemical Tests

Test	No. of Dogs Tested	No. of Dogs (%) Below Reference	No. of Dogs (%) Within Reference	No. of Dogs (%) Above Reference	Range	Reference Range*
Total protein (g/dL)	36	4 (11)	31 (86)	1 (3)	3.4-7.7	4.8-7.5
Albumin (g/dL)	36	3 (8)	33 (92)	0	1.5-3.1	2.2-3.9
Glucose (mg/dL)	36	6 (17)	23 (64)	7 (19)	33-488	67-132
BUN† (mg/dL)	36	5 (14)	25 (69)	6 (17)	3-67	7-32
Creatinine (mg/dL)	36	4 (11)	29 (81)	3 (8)	0.3-3.5	0.5-1.7
Calcium‡ (mg/dL)	35	3 (8)	32 (91)	0	8.7-10.7	9.1-12.3
Bicarbonate§ (mmol/L)	36	3 (8)	24 (67)	12 (33)	6-39	13-25
ALT\ (U/L)	36	1 (3)	20 (56)	15 (42)	3-4999	3-109
ALP¶ (U/L)	36	0	6 (17)	30 (83)	24-14,190	1-151
Amylase (U/L)	27	0	10 (37)	17 (63)	639-6135	226-1063
Lipase (U/L)	23	0	11 (48)	12 (52)	179-14,018	104-1753
Total bilirubin (mg/dL)	20	0	10 (50)	10 (50)	0.1-15.4	0-0.8

* Each value was compared to the respective reference range from the reporting laboratory. For the purposes of this table, the entire range covered by the reference intervals of the reporting laboratories is listed.

† BUN=blood urea nitrogen

‡ Total adjusted calcium concentration (mg/dL) = total calcium concentration (mg/dL) – albumin concentration (g/dL) + 3.5

§ Fourteen cases had total carbon dioxide (TCO₂) measured, but bicarbonate was not measured. The TCO₂ measurements are included here.

\ ALT=alanine aminotransferase

¶ ALP=alkaline phosphatase

were available for 20 dogs. When the difference between preoperative and postoperative albumin concentrations was examined, the magnitude of increase in postoperative albumin concentrations did not have a significant influence on outcome, but a strong trend was noted (OR 11.25; CI 0.76 to 167.3; $P=0.079$). Neither the preoperative nor the postoperative PSS had a significant influence on outcome; the magnitude of change between the two scores also had no significant influence on outcome.

Coagulation Testing

Activated clotting times were performed in four dogs and were prolonged in all four. Prothrombin time and APTT were measured in 13 dogs. Prolonged PT was reported in two dogs, and prolonged APTT was reported in six. Thrombin time was measured in six dogs and was normal in all six. Because of the insufficient number of dogs that had

coagulation profiles performed, the significance of abnormal APTT or TT could not be evaluated. The APTTs did not significantly influence outcome, regardless of whether they were evaluated based on degree of prolongation or categorized as normal or abnormal.

Abdominocentesis

Abdominocentesis was performed in 14 dogs. A complete fluid analysis was available for five samples, and the remaining nine samples were only examined cytologically. Cytology was purulent in 11 samples and septic in three. When total fluid analyses were performed, the fluids ranged from a modified transudate to an exudate.

Bacteriology

The pancreas itself or necrotic debris associated with the pancreas was cultured at the time of the initial surgery in 13

dogs. Cultures were positive in two cases, one for *Staphylococcus saprophytes* and one for *Klebsiella pneumoniae*. The abdominal cavity was cultured at the time of initial surgery in 12 dogs; seven samples yielded bacterial growth. Isolated bacteria included *Escherichia (E.) coli* (n=3), *Enterococcus* spp. (n=2), *Pseudomonas aeruginosa* (n=2), *Streptococcus* sp. (n=2), *Pseudomonas cepacia* (n=1), and *Bacteroides* sp. (n=1). In three dogs, both the abdomen and the pancreas were cultured at the time of surgery. In one dog, both cultures were negative. However, in two dogs the pancreas or associated mass was negative when the abdomen yielded growth. Of the three dogs with septic abdominocentesis, abdominal cultures were available in two dogs, and both samples yielded growth. A positive bacterial culture did not significantly influence outcome. Cultures of bile (n=3), blood (n=1), and kidney tissue (n=1) were taken; all were negative for bacterial growth. Of the three urine cultures performed, only one was positive (*E. coli*).

Diagnostic Imaging

Thoracic radiographs were available for 21 dogs. Parenchymal changes in the lung included an interstitial pattern (n=8), a bronchial pattern (n=4), and an alveolar pattern (n=1). One dog had pulmonary edema, and three had pleural effusion. Two dogs had cardiomegaly and one had microcardia. In summary, 11 (52%) of 21 dogs had parenchymal change or pleural effusion. Ten (48%) of 21 studies were considered normal. Follow-up radiographs were taken postsurgery in two cases. Both dogs previously had bronchointerstitial patterns and had subsequently developed alveolar disease; both dogs died. Of the 11 dogs with parenchymal changes or pleural effusion, six died, three were euthanized, and two survived to discharge. Of the 10 dogs without parenchymal changes or pleural effusion, one died, four were euthanized, and five survived to discharge. Parenchymal changes or pleural effusion did not have a significant influence on outcome.

Abdominal radiographs were available for 33 dogs. Ten studies revealed decreased serosal detail in the cranial abdomen. Nine dogs had peritoneal effusion, 10 had a mass effect at the pancreas, five had radiographic evidence of intestinal ileus, and six had generalized hepatomegaly. Three studies were normal. Two of the dogs with peritoneal effusion also had pleural effusion.

Abdominal ultrasonography was performed in 27 dogs. For one dog, the study was "nondiagnostic due to obesity;" this study was excluded from analysis. Ten of 26 dogs had a hypoechoic pancreas; one dog had a hyperechoic pancreas. A pancreatic mass was observed in 14 dogs. Other significant findings included a mass of mixed echogenicity not directly related to the pancreas (n=3); evidence of free peritoneal fluid (n=4); a hypoechoic or anechoic cavity near or related to the pancreas (n=2); evidence of biliary obstruction (n=8); and an increased hepatic echogenicity (n=4). One dog had no significant findings reported. Of the 14 dogs in which a pancreatic mass was reported, three died, five were euthanized, and six survived to discharge. Of the

12 dogs in which a pancreatic mass was not reported, five died, five were euthanized, and two survived to be discharged. No radiographic or ultrasonographic finding in the abdomen had a significant influence on clinical outcome.

Surgery

All dogs had at least one laparotomy. Recorded indications for surgery included a pancreatic mass observed via ultrasonography (n=16); a mass effect seen on survey radiographs (n=2); exploration (n=4); peritonitis (n=3); septic peritonitis (n=3); exploration with jejunostomy tube placement (n=1); severe cholestasis or gallbladder obstruction (n=2); acute abdomen (n=2); small intestinal biopsy (n=1); gastric outflow obstruction (n=1); and an unspecified indication (n=1).

The pancreas was débrided in 13 dogs; partial pancreatectomies were performed in three dogs; and 20 dogs had pancreatic biopsies taken. Duodenostomy tubes were placed in three dogs, and seven dogs received jejunostomy tubes. Sump-Penrose drains were placed in five dogs, and 11 were managed with open abdominal drainage. At the initial surgery, adhesions were visible in 14 dogs, and gross evidence of diffuse peritonitis was seen in three. Results of histopathological analyses of pancreata are summarized in Table 5.

A second surgery was performed in nine dogs; two dogs had additional débridement of the pancreas, and seven dogs had closure of an open abdomen. Two dogs had three surgeries for repeated débridement and subsequent closure, and two dogs had four surgeries for débridements and eventual closure. Overall, 23 (64%) of 36 dogs had one surgery, and 13 (36%) of 36 dogs had multiple surgeries. All surgeries were performed in the same hospitalization episode. All dogs that underwent open abdominal drainage had the abdominal cavity closed 2 to 7 days after the previous surgery. Of the 13 dogs that underwent more than one laparotomy, two died, three were euthanized, and eight survived to be discharged. Of the 11 dogs that underwent only one laparotomy, three died, two were euthanized, and six survived to be discharged. Multiple surgical procedures did not significantly influence outcome. No difference was seen in outcome between dogs managed with an open abdomen and those managed with sump-Penrose drains. Likewise, no difference was seen in outcome for dogs managed with open abdominal drainage or sump-Penrose drainage and those managed with primary closure.

Treatment

All dogs were treated with intravenous fluids, and 33 (92%) of 36 dogs received intravenous antibiotics. Twelve dogs were treated with heparin for an average of 3.8 ± 2.3 days; administration of heparin therapy did not influence outcome. Nineteen dogs received pain medication for an average of 2.4 ± 2.6 days. Twelve dogs received nutritional support; nutrition was delivered via jejunostomy tube (n=8), via duodenostomy tube (n=1), and via total parenteral nutrition (TPN; n=4). One dog received TPN presurgery and

Table 5
Summary of Histopathological Findings

Case No.	Histopathology
1	Pancreatic fibrosis, lobular fibrosis, cholestasis
2	Not performed
3	Marked pancreatic necrosis and peripancreatic fat necrosis
4	Purulent inflammation of pancreas with peripancreatic fat necrosis
5	Fibrosing, granulomatous, eosinophilic pancreatitis
6	Peripancreatic fat necrosis
7	Not performed
8	Pancreatic necrosis and fibrosis with multifocal peripancreatic fat necrosis
9	Purulent pancreatic inflammation and chronic fibrosing interstitial pancreatitis
10	Chronic, necrotizing pancreatitis with peripancreatic steatitis
11	Severe, diffuse necrotizing pancreatitis
12	Chronic-active pancreatitis with purulent inflammation
13	Severe, chronic necrotizing pancreatitis
14	Pancreatic fibrosis, peripancreatic necrosis, and purulent peritonitis
15	Pancreatic fibrosis
16	No abnormalities reported
17	Pancreatic fibrosis with fibrovascular proliferation and peripancreatic necrotizing steatitis
18	Necrotic intestinal leiomyosarcoma; no pancreas submitted
19	Focal pancreatic necrosis
20	Pancreatic necrosis
21	Purulent necrotizing pancreatitis
22	Purulent pancreatic inflammation with necrotic peripancreatic fat
23	Peripancreatic fat necrosis
24	Not performed
25	Chronic-active necrotizing pancreatitis and steatitis with evidence of sepsis
26	Necrotizing peripancreatic steatitis and lymphoid hyperplasia
27	Widespread pancreatic fibrosis with multiple sites of neutrophilic inflammation
28	Peripancreatic steatitis
29	Chronic fibrosing pancreatitis
30	Histopathological examination performed, but results not available
31	Multifocal, acute pancreatic inflammation with chronic-active, necrotizing peripancreatic steatitis
32	Histopathological examination performed, but results not available
33	Not performed
34	Acute necrotizing pancreatitis
35	Multifocal, necrotizing pancreatitis with marked fibrosis
36	Chronic fibrosing, necrotizing pancreatitis with necrotizing steatitis

jejunostomy tube feedings postsurgery. Nutritional support, regardless of route of administration, did not have an effect on outcome. Colloid support included plasma transfusions (n=18) and hetastarch administration (n=5). One dog received a transfusion of packed red blood cells, and five dogs received whole blood transfusions. Comparison of dogs that received colloid support to those that did not yielded an OR for death or euthanasia of 4.15 (CI 0.743 to 23.229; $P=0.10$).

Outcome

Six (17%) dogs were euthanized at the time of initial surgery. Eight (22%) dogs were euthanized postoperatively; times from surgery to euthanasia in this group were <24 hours (n=2), 24 hours (n=1), 7 days (n=1), 9 days (n=2), 10 days (n=1), and 15 days (n=1). Eight (22%) dogs died, and 14 (39%) dogs were discharged alive. Overall, the number of days in the hospital ranged from 1 to 21 (mean 8.2 ± 5.8 days). The number of days in an intensive care unit ranged from 1 to 21 (mean 6.1 ± 4.8 days). Of those dogs surviving to discharge, the number of days in the hospital ranged from 3 to 21 (mean 12.4 ± 4.7 days). Only two dogs were hospitalized <9 days (one for 3 days and one for 6 days).

Follow-up

Of the 14 dogs discharged alive, follow-up information was obtained for nine dogs from recheck examinations or phone consultation with the owner. One dog was euthanized 2 months after discharge for persistent vomiting and diarrhea. Two dogs were euthanized 2 and 5 years later for unrelated diseases. One dog developed hyperadrenocorticism and hypothyroidism; one dog developed hypothyroidism; and one dog developed diabetes mellitus and exocrine pancreatic insufficiency. With the exception of the dog euthanized for persistent vomiting, owners of these dogs and three other owners were reportedly happy with the quality of life for their animals. Follow-up time ranged from 2 months to 7 years.

Discussion

The major limitations of this study are related to its retrospective nature and the variation in treatment protocols utilized. Although a statistical significance was demonstrated between elevated BUN and ALP values and a negative outcome, it is difficult to apply this finding to clinical case management. The significant influence of elevated BUN concentrations suggests such cases were at a disadvantage due to concurrent renal disease; however, in all cases with abnormal preoperative BUN concentrations, both the BUN and serum creatinine values decreased to within normal levels postoperatively. The data are unavailable to determine whether this was due to the administration of intravenous fluids and subsequent diuresis of a dog with renal insufficiency, or due to resolution of prerenal azotemia. It is important to note that the significance was only demonstrated when the BUN concentration was analyzed as a binary variable; that is, when it was categorized as "normal" (within the reference interval of the reporting laboratory) or

"abnormal" (outside of the reference interval of the reporting laboratory). All abnormal BUN values were above the given reference interval. The magnitude of BUN elevation did not have a significant influence on outcome. Likewise, a significant influence of serum ALP activity was only demonstrated when the values were analyzed as binary variables; the magnitude of elevation of serum ALP activity did not have a significant influence on outcome.

A negative correlation was demonstrated between bicarbonate ion concentration and survival; statistically, this means that as an animal's TCO_2 or bicarbonate ion concentration decreases, its chances of survival increase. Because of the available tests performed by the laboratories used during this time period, total CO_2 concentrations were substituted for bicarbonate ion concentrations in 14 of the cases, making interpretation of lower bicarbonate levels and better clinical outcome less trustworthy. Blood gas analyses were not available for evaluation of blood pH.

Similar to previous reports, cultures of pancreatic tissue rarely yielded bacterial growth.¹⁻⁴ In the authors' study, only two (15%) of 13 cultures of pancreatic tissue or exudates yielded bacterial growth. Previously reported frequencies of positive culture results at initial surgical exploration vary in range: zero of five, one of seven, three of 12 (all three considered contaminants), and two of nine.¹⁻⁴ However, unlike other reports, peritoneal fluid was cultured in 12 of the 36 dogs included in this study; seven of these 12 cultures yielded bacterial growth. Two of these seven dogs with positive peritoneal fluid cultures had a prior surgery, and one of the two dogs with positive pancreatic tissue cultures had a prior surgery. Three dogs had both pancreatic tissue and peritoneal fluid cultured. In two of these dogs, culture of pancreatic tissue yielded no bacterial growth, while culture of the peritoneal fluid obtained at the same surgery yielded bacterial growth. Neither of the two dogs had a prior surgery that may have resulted in bacterial contamination. These results raise the possibility of an undiagnosed septic peritonitis in the face of what appears to be sterile pancreatic necrosis, and the viability of culturing purulent material is questioned.

The role of perioperative antibiotics in obtaining negative culture results has been questioned previously.^{1,3} Twenty-five of 36 dogs received antibiotic therapy from a referring veterinarian prior to admission. Medical records were not sufficient to determine the exact perioperative antibiotic regimen for each case.

Pancreatic necrosis, phlegmon, and abscess formation have been documented as sequelae to severe pancreatitis.^{1,2,6,7} Because of this relationship, the possible relationship between the PSS and outcome of pancreatic abscess formation was investigated. Similar to the findings of Johnson and Mann, the preoperative PSS did not have a significant correlation to clinical outcome in these cases.³ The postoperative PSS was also calculated when possible. Neither the postoperative PSS nor the magnitude of improvement (if any) in pre- and postoperative PSS had a significant correlation to outcome. This scoring system was

developed to assess acute pancreatitis; as such, it likely underestimates the severity of pancreatic abscesses that possibly represent a more chronic manifestation of pancreatic disease.

No significant benefit of utilizing abdominal drainage techniques was seen in the authors' study. This finding is similar to that reported by Johnson and Mann.³ The small number of dogs in that study prevented demonstration of a significant advantage of omentalization over open abdominal drainage; however, the feasibility of omentalization and primary abdominal closure was demonstrated.

Although the administration of colloids approached having a significant negative impact on survival, it is likely that the population of dogs receiving colloid support is biased toward a worse outcome simply because of the clinical implications associated with their need for colloid support. This idea is supported by the findings associated with postoperative albumin concentrations. Though significance was not reached, a postoperative increase in albumin approached having a positive influence on survival (OR 11.25; CI 0.76 to 167.3; $P=0.079$). Significance was not achieved possibly because of the sample size; postoperative albumin concentrations were available for 20 dogs.

This study also demonstrated a prolonged hospitalization time for dogs affected with pancreatic abscesses. The mean duration of hospitalization for surviving dogs was 12.4 days; only two of these dogs were discharged prior to the 9th day of hospitalization. Although the length of hospitalization did not influence outcome, this study highlights the importance of preparing owners for long, intensive therapy.

Nutritional support did not influence outcome in these dogs for several reasons. Only 12 of the 36 dogs received nutritional support, and this low number may misrepresent the true value of nutritional support. Also, it is not possible to know whether severity of illness influenced individual surgeons to administer nutritional support, thereby causing a bias in the population of dogs that received such support.

Conclusion

Based on the findings of this retrospective study, no strong predictors of mortality are apparent in the diagnosis and treatment of pancreatic abscesses.

Footnotes

^a SAS, Version 9.1; SAS Institute, Inc., Cary, NC 27513-2414

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