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STANDARD ARTICLE

A retrospective study of 157 hospitalized cats with pancreatitis in a tertiary care center: Clinical, imaging and laboratory findings, potential prognostic markers and outcome

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Background: Pancreatitis in cats (FP) has been increasingly diagnosed in recent years, but clinical studies of large numbers of affected cats are scarce.

Objectives: To describe a large cohort of cats with FP requiring hospitalization.

Animals: One hundred and fifty-seven client-owned cats.

Methods: Retrospective study, including cats diagnosed with pancreatitis based on sonographic evidence, positive SNAP feline pancreatic lipase immunoreactivity test results, increased 1,2-o-dilauryl-rac-glycerol-glutaric Acid-(6′-methylresorufin ester)-lipase activity, histopathology, or some combination of these.

Results: One-hundred and twenty-two cats (77.7%) survived to discharge.

Median time from onset of clinical signs to presentation was longer (P = .003) in nonsurvivors. Causes of FP included recent general anesthesia, trauma, hemodynamic compromise, and organophosphate intoxication, but most cases (86.6%) were idiopathic. Ultrasonographic findings consistent with pancreatitis were documented in 134 cats, including pancreatomegaly (81.3%), decreased (31.3%), or increased (14.9%) pancreatic echogenicity, extra-hepatic biliary tract dilatation (24%), and increased peri-pancreatic echogenicity (13%). Lethargy (P = .003), pleural effusion (P = .003), hypoglycemia (P = .007), ionized hypocalcemia (P = .016), azotemia (P = .014), parenteral nutrition administration (P = .013), and persistent anorexia during hospitalization (P = .001) were more frequent in nonsurvivors, whereas antibiotics were more frequently administered to survivors (P = .023). Nevertheless, when Bonferroni's correction for multiple comparisons was applied, none of the variables was statistically significant.

Conclusions and Clinical Importance: Previously unreported, clinically relevant, potential prognostic factors, including hypoglycemia, azotemia, parenteral nutrition, and withholding antibacterial treatment were identified in this exploratory study. These preliminary results should be examined further in confirmatory studies.

KEYWORDS

antibiotics, azotemia, feline, hypocalcemia, hypocarbemia, hypoglycemia

Abbreviations: AKI, acute kidney injury; ANP, acute necrotizing pancreatitis; AP, acute pancreatitis; aPTT, activated partial thromboplastin time; ASP, acute suppurative pancreatitis; BCS, body condition score; BW, body weight; CK, creatine kinase; CKD, chronic kidney disease; CP, chronic pancreatitis; DGGR-lipase, 1,2-o-dilauryl-rac-glycerol-glutaric Acid-(6′-methylresorufin ester) lipase; DIC, disseminated intravascular coagulation; DKA, diabetic ketoacidosis; DM, diabetes mellitus; FP, feline pancreatitis; fPLI, feline pancreatic lipase immunoreactivity; HL, hepatic lipidosis; IBD, inflammatory bowel disease; IQR, interquartile range; PN, parenteral nutrition; PT, prothrombin time; RI, reference interval; TCO_2, total CO_2; TPN, total parenteral nutrition

1 | INTRODUCTION

Pancreatitis in cats (FP) is thought to be underdiagnosed because of its nonspecific clinical signs and low sensitivities of available diagnostic tests.[1–3] With increased awareness, the advent of improved imaging technology and introduction of more sensitive laboratory tests, antemortem diagnosis of FP has increased.[2,4] Owing to the nonspecific signs of acute (AP) and chronic (CP) pancreatitis, overlapping with those of many other diseases, the diagnosis of FP is based on compatible clinical signs and corroborative laboratory and imaging findings.[4,5] Ultrasonographic changes in pancreatic echogenicity and size, increased peripancreatic echogenicity, free or peri-pancreatic abdominal fluid accumulation, and dilated pancreatic and bile ducts are suggestive of pancreatic inflammation.[4,6–8] Concurrent increases in serum pancreatic lipase activity, including 1,2-o-dilauryl-rac-glycerol-glutaric acid-(6′-methylresorufin)-ester (DGGR) lipase or feline pancreatic lipase immunoreactivity (fPLI) are supportive of FP.[4,5,9,10] These markers, although relatively specific for pancreatitis, often have unsatisfactory sensitivity.[4,5]

Three histologically distinct forms of FP are recognized, including acute necrotizing pancreatitis (ANP), acute suppurative pancreatitis (ASP) and CP.[1,2,11–13] Histologically, ANP and ASP cases may have concurrent fibrosis (a diagnostic criterion of CP[1]), whereas ultrasonographically, proposed criteria of CP (eg, increased pancreatic echogenicity) and AP (eg, pancreatomegaly, hypoechoic pancreas, increased peripancreatic mesenteric echogenicity and fluid) are found in both forms of FP.[8,11] The clinical ramifications of such distinctions are similarly unclear. Chronic pancreatitis is thought to be milder in clinical presentation, of longer duration, and may remain subclinical, as reflected by the high prevalence of pancreatic histologic lesions in apparently healthy cats.[1] Long-standing sequelae of CP include exocrine pancreatic insufficiency and diabetes mellitus (DM),[12] and CP often is associated with concurrent chronic inflammatory hepatobiliary and intestinal diseases.[1,11,14–16] Conversely, AP, specifically ASP, is associated with younger age of onset and worse prognosis.[13] However, AP and CP are often clinically indistinguishable,[11] sharing similar history, clinical, laboratory, and imaging findings. Furthermore, CP may present with acute "flare-ups" of the disease, mimicking AP, whereas recurrent AP episodes likely contribute to development of CP.[1,12,17]

Several factors are implicated in FP, including prior general anesthesia, hypoperfusion, organophosphate intoxication, pancreatolithiasis, infection and trauma, but most cases are idiopathic.[2,13,17–20]

The consequences of AP may be devastating, as pancreatic zymogens are activated, and an inflammatory storm ensues.[12,17] The deleterious effects of active pancreatic enzymes on cellular membranes, endothelium, adipose tissue, and the coagulation cascade can result in tissue damage, necrosis, disseminated intravascular coagulation (DIC), thrombosis, edema formation, and hypoxia.[12,17,21–23] The fatality rate of AP in cats ranges from 9% to 41%.[24–26] However, despite increased awareness and improved diagnostic capability, recent, large-scale clinical studies of FP are scarce, hampering our understanding of its presentation and management. Some clinical studies were published >15 years ago, and others are limited in size (≤20 cases) or scope (ie, focusing on pancreatitis in cats with concurrent DM or inflammatory bowel disease [IBD]). Therefore, we conducted a comprehensive retrospective study in a large heterogeneous cohort of cats with FP requiring hospitalization and investigated potential prognostic factors.

2 | MATERIALS AND METHODS

2.1 | Cats and definitions

Our study was conducted at a tertiary referral teaching hospital. Medical records of cats diagnosed with FP between 2008 and 2014 were retrospectively retrieved. Any cat that presented with clinical signs compatible with FP (eg, anorexia, lethargy, vomiting, diarrhea, icterus) and diagnosed with pancreatitis was considered eligible for enrollment in the study, contingent upon fulfilling at least 1 of the following criteria: a positive SNAP fPL test (Feline SNAP fPLI, IDEXX Europe B.V., Hoofddorp, the Netherlands), increased DGGR-lipase activity (reference interval [RI] <26 U/L), compatible abdominal ultrasonographic findings, histopathological diagnosis of pancreatitis, or some combination of these.

The sonographic diagnosis of pancreatitis was based on presence of >2 of the following findings: pancreatomegaly, pancreatic echogenicity and echotexture abnormalities, irregular pancreatic contours, surrounding hyperechoic mesentery, peri-pancreatic fluid accumulation, pancreatic mineralization, and irregular or abnormal pancreatic duct dilatation.[6–8,27–29] Acute kidney injury (AKI) and chronic kidney disease were diagnosed based on the International Renal Interest Society guidelines (http://iris-kidney.com/guidelines/staging.html) and grading system (http://www.iris-kidney.com/pdf/grading-of-acute-kidney-injury.pdf).

Survivors were defined as alive at discharge, whereas nonsurvivors included cats that died or were euthanized during hospitalization because of deterioration, despite ongoing treatment.

2.2 | Collection of samples and laboratory methods

Blood samples for serum chemistry (Cobas Integra 400 Plus; Cobas 6000, Roche, Mannheim, Germany) including DGGR-lipase and SNAP fPL, CBC (Advia 120 or 2120, Siemens, Erfurt, Germany; Abacus Junior Vet, Diatron, Wien, Austria) and hemostatic tests (prothrombin time [PT] and activated partial thromboplastin time [aPTT]; ACL-9000, IL, Milano, Italy; KC-1 micro, Amelung, Lemgo, Germany) were collected in plain tubes with gel separators, potassium-EDTA and 3.2% trisodium-citrate tubes, respectively. Blood smears were prepared and stained with modified Wright's staining solution (Modified Wright's stain, Bayer Hematek 2000 Slide Stainer, Siemens, Elkhart, Indiana), and used for microscopic evaluation of blood cells, including a manual platelet count, and for excluding platelet clumping as a cause for spurious thrombocytopenia. When platelet clumping was observed, the platelet count was excluded from statistical analyses. Differential leukocyte counts were only included when generated by the Advia analyzer after admission to the hospital. In 44 of the cats (28%), when the CBC had been performed by referring veterinarians within 24 hours of admission to the hospital, it was not repeated, and hematological data (excluding the differential leukocyte count) provided by the referring veterinarians were included in the study.

2.3 | Statistical analyses

The Kolmogorov-Smirnov test was used to examine the distribution pattern of quantitative variables. Normally and non-normally distributed variables are presented as mean ± SD or median and interquartile range (IQR), respectively. Quantitative variables were compared between 2 independent groups by the Student *t* test or the Mann-Whitney *U* test, for normally and non-normally distributed variables, respectively. The association between 2 qualitative variables was examined using the χ^2 or the Fisher exact tests. The Bonferroni method for correcting the significance level for multiple comparisons was applied. Variables that were statistically (unadjusted $P < .2$) associated with death were subjected to a series of forward multivariable analyses to further examine their association with outcome. One set of models used diagnostic tests to predict the odds of death (retaining amylase in all models as a biomarker of pancreatitis) and a second set of models used clinical signs to predict the odds of death. All tests were 2-tailed. Analyses were done using statistical software packages (SPSS 22.0 for Windows, IBM, Chicago, Illinois; LogXact 11, Cytel Software Corporation, Cambridge, Massachusetts; Stata 15/IC, StataCorp, College Station, Texas).

3 | RESULTS

The study included 157 cats, 94 males (59.9%; neutered, 82; 87%) and 63 females (40.1%; neutered, 55; 87%), with significant ($P = .016$) male overrepresentation compared to the expected 1:1 female: male ratio. Most cats (105; 66.9%) were domestic shorthair. Additional breeds, in decreasing order of frequency, included Persian (19; 12.1%), Siamese (8; 5.1%), British shorthair (4; 2.5%), and other breeds (21; ≤3 cats each). The mean age was 9.5 ± 5.1 years. In our study, 144 variables initially had been compared between survivors and nonsurvivors, and therefore, when the Bonferroni's correction of the significance level ($P < .05$) was applied, the adjusted significance level was .00034. Consequently, all of the results of these comparisons became statistically insignificant. In the following results section, the reported *P* values are unadjusted. No significant breed, age, sex or neuter status differences were found between survivors and nonsurvivors ($P = .52$, $P = .43$, $P = .44$, and $P = .89$, respectively). Mean body weight (BW) of survivors was higher ($P = .025$) compared to nonsurvivors (4.4 kg ±1.4 vs 3.8 kg ±1.3, respectively), but body condition score (BCS; using a 1-9 scale) did not differ between these groups (3.8 ±1.5 vs 3.3 ± 1.7, respectively; $P = .13$).

Forty-three cats (27.4%) had outdoor access, whereas 114 (72.6%) were strictly indoors. Dietary history was available in 154 cats, of which 121 (78.6%) were strictly fed commercial kibble, 7 (4.5%) were strictly fed home-made diets, and the remainder were fed combinations thereof. Neither outdoor access ($P = .26$) nor diet type ($P = .12$) was associated with survival. The median time from onset of clinical signs to presentation was 5 days (IQR, 3-10), and was longer ($P = .003$) in nonsurvivors (median, 7 days; IQR, 3-21) compared to survivors (median, 4 days; IQR, 2-7). The duration of clinical signs from onset to presentation was weakly and negatively correlated with BW ($rs = -0.187$; $P = .019$) and with the BCS ($rs = -.203$; $P = .014$).

Dehydration (127/157 cats; 84.7%), lethargy (114/157; 72.6%), and anorexia (97/157; 61.8%) were commonly observed. Other signs, in decreasing order of frequency included vomiting, owner-reported weight loss, hypothermia, tachypnea, icterus, inappetence, abdominal pain, diarrhea, and fever (rectal temperature, >39.5°C; Table 1). Lethargy was more frequent ($P = .003$) in nonsurvivors compared to survivors. Fever ($P = .042$) and weight loss ($P = .034$) were more frequent in survivors (Table 1). Occurrence of fever was lower in azotemic cats ($P = .005$) and in those diagnosed with AKI ($P = .023$). Six cats had seizures, of which 2 experienced hypoglycemia (blood glucose concentration <20 mg/dL), and 1 had hypocalcemia (ionized calcium concentration = 0.674 mmol/L).

Pancreatitis was confirmed by positive SNAP fPLI test alone in 16 cats (10.2%) and by abdominal ultrasonography alone in 115 (73.2%). In 22 cats (14%), either a positive SNAP fPLI test (15 cats) or DGGR-lipase (7 cats), in addition to positive abdominal ultrasonography, were confirmatory of pancreatitis. In 8 cats (5.1%), pancreatitis was confirmed histopathologically by surgically obtained pancreatic tissue biopsy specimens, or at necropsy. In 1/8 cats, ultrasonography also was performed, whereas in 3/8 cats, either a positive SNAP fPLI or DGGR-lipase confirmed pancreatitis, in addition to histopathology.

Putative etiologies of pancreatitis (21 cats; 13.4%) included recent general anesthesia (10 cats; 6.4%), trauma (6; 3.8%), hemodynamic compromise secondary to heart failure, urinary obstruction or gastrointestinal foreign body (4; 2.5%), and organophosphate intoxication (1).

Abnormalities on the CBC (Table 2) included lymphopenia (44/64 cats; 68.7%), eosinopenia (43/64; 67.2%), leukocytosis (42/153; 27.5%), anemia (30/150; 20%), neutrophilia (23/64; 36.0%), leukopenia (20/153; 13.1%), and thrombocytopenia (13/114; 8.5%). Neutrophil cytoplasmic toxicity (66/127 cats; 51.9%) and left shift (49/127; 38.6%) were common.

Numerous serum biochemistry abnormalities were documented in most cats (Tables 3 and 4), including hyponatremia (104/139 cats; 74.8%), hyperglycemia (101/144; 70.1%), hypochloremia (91/132; 68.9%), hyperbilirubinemia (80/142; 56.3%), hypertriglyceridemia (57/104; 54.8%), decreased total CO_2 (TCO_2) concentration (43/94; 45.7%), hyperketonemia (24/54; 44.4%), and increased activities of creatine kinase (CK; 62/105; 59%), aspartate transaminase (62/119; 52.1%), and alanine transaminase (61/146; 41.8%). The frequency of hyperphosphatemia (30.8%) approximated that of azotemia (increased creatinine concentration, 31.6%; increased urea concentration, 44.5%). Median serum glucose concentration was lower ($P = .022$) in nonsurvivors compared to survivors (Table 3). Frequency of increased serum creatinine concentration (>1.6 mg/dL) was higher ($P = .014$) in nonsurvivors (21/35 cats; 60%) compared to survivors (44/120, 36.7%). In nonsurvivors, the frequencies of hypoglycemia (4/32 cats; 12.5%) and ionized hypocalcemia (4/18 cats; 22.2%) were higher compared to survivors (2/112 cats; 1.8% and 3/66 cats; 4.5%, respectively; $P = .007$ and $P = .016$, respectively). Concurrent AKI was documented in only 1 of 7 cats with ionized hypocalcemia. When performed, PT and aPTT were prolonged in most cats, with no significant group differences (Table 3).

Ultrasonographic findings consistent with pancreatitis were documented in 134 cats, including pancreatomegaly (109 cats; 81.3%) and decreased (42; 31.3%) or increased (20; 14.9%) pancreatic echogenicity. Extra-hepatic biliary dilatation, pancreatic duct dilatation, and

TABLE 1 Selected history and physical examination findings at presentation in 157 cats with pancreatitis

Clinical sign	Survivors (n = 122) n (%)	Nonsurvivors (n = 35) n (%)	All cats (n = 157) n (%)	*P* value[a]
Dehydration	95 (81.9)	32 (94.1)	127 (84.7)	.082
Weakness or lethargy	86 (70.5)	28 (80.0)	114 (72.6)	.266
Anorexia	76 (62.3)	21 (60.0)	97 (61.8)	.805
Vomiting	62 (50.8)	18 (51.4)	80 (51.0)	.949
Weight loss	42 (34.4)	19 (54.3)	61 (38.9)	.034
Hypothermia (rectal temp. <37.5°C)	44 (36.3)	16 (47)	60 (38.7)	.300
Tachypnea (respiratory rate >40)	41 (33.6)	10 (28.6)	51 (32.5)	.575
Icterus	31 (25.4)	10 (28.6)	41 (26.1)	.707
Decreased appetite	27 (22.1)	10 (28.6)	37 (23.6)	.429
Abdominal pain	29 (23.8)	6 (17.1)	35 (22.3)	.406
Diarrhea	25 (20.5)	6 (17.1)	31 (19.7)	.661
Polyuria and polydipsia	18 (14.8)	6 (17.1)	24 (15.3)	.729
Cardiac murmur	19 (15.6)	3 (8.6)	22 (14.0)	.293
Fever (rectal temp. >39.5°c)	19 (15.7)	0 (0.0)	19 (12.2)	.042
Lymphadenomegaly	12 (9.8)	3 (8.6)	15 (9.6)	.822
Abnormal lung sounds	10 (8.2)	3 (8.6)	13 (8.3)	.097
Cranial abdominal organomegaly	10 (8.2)	2 (5.7)	12 (7.6)	.626
Abdominal distension	12 (9.8)	0 (0.0)	12 (7.6)	.054
Dyspnea	7 (5.7)	3 (8.6)	10 (6.4)	.545
Lethargy or obtundation[b]	4 (3.3)	6 (17.1)	10 (6.4)	.003
Hypersalivation	6 (4.9)	3 (8.6)	9 (5.7)	.412
Collapse	4 (3.3)	2 (5.7)	6 (3.8)	.871
Hematemesis	4 (3.3)	2 (5.7)	6 (3.8)	.871
Hematuria	5 (4.1)	1 (2.9)	6 (3.8)	1.000
Constipation	4 (3.3)	2 (5.7)	6 (3.8)	.871
Seizures	4 (3.3)	2 (5.7)	6 (3.8)	.871
Hematochezia	4 (3.3)	1 (2.9)	5 (3.2)	1.000

Clinical signs are shown only if present in ≥5 cats.
[a] When the Bonferroni method was employed for correcting for the significance level for 144 comparisons made in this study, the adjusted significance level was .00034, rendering all results statistically insignificant.
[b] Mental status information was available in 155 cats.

increased peri-pancreatic echogenicity were noted in 32 (24%), 15 (11%) and 17 (13%) cats, respectively.

Comorbidities and complications were identified commonly, including hepatobiliary, renal, intestinal, endocrine, and cardiovascular diseases (Table 5). Pleural effusion (P = .003) was more frequently identified in nonsurvivors compared to survivors (Table 5). Persistent anorexia during hospitalization was a negative prognostic factor (survivors, 1/116; 0.9% vs nonsurvivors, 5/33; 15.2%; P = .001). During hospitalization, parenteral nutrition (PN) was administered to 9 cats, of which 8 received only amino acid-containing products, and 1 cat received complete PN. Parenteral nutrition was administered more frequently (P = .013) to nonsurvivors (5/33 cats; 15.2%) compared to survivors (4/116 cats; 3.4%), whereas antibiotics were more frequently (P = .023) administered to survivors (119/122 cats; 97.5%) compared to nonsurvivors (31/35 cats; 88.6%).

One-hundred and twenty-two cats (77.7%) survived to discharge. Among the 35 nonsurvivors, 16 (46%) died during hospitalization, whereas 19 (54%) were euthanized because of clinical deterioration.

Variables associated with increased odds of death and with a P < .2, including duration of clinical signs before presentation, weight loss, rectal temperature at presentation, RBC count, serum amylase activity, glucose, TCO_2, creatinine, iCa, PT, seizures, AKI and pleural effusion during hospitalization, absence of voluntary eating during hospitalization, withholding antibiotic treatment, and PN administration, were evaluated in multivariable logistic regression analyses. In a diagnostic test model that included serum glucose concentration while controlling for amylase concentration, the former (categorized based on 20 mg/dL increments) remained significant (P = .02; odds ratio [OR], 0.87, 95% confidence interval [CI], 0.75-0.98). For an increase of 20 mg/dL in serum glucose concentration, the odds of death decreased by 13%. In a clinical signs model that included absence of voluntary eating during hospitalization (OR, 2.80; 95% CI, 2.56-207.4) and duration of clinical signs before presentation to the hospital (OR, 2.25; 95%, 1.002-1.038), both variables remained significantly associated with increased odds of death (P = .024 and P = .005, respectively).

4 | DISCUSSION

Pancreatitis in cats encompasses a heterogeneous group of histological entities, for which ante-mortem diagnosis is rarely achieved.[2]

TABLE 2 Complete blood count results and clotting times of cats with pancreatitis at presentation

Analyte[a]		Survivors	Nonsurvivors	All cats	Reference interval	*P* value[b]	*P* value[c]
Leukocytes (x10^3/μL)	n (%)	119 (77.8)	34 (22.2)	153	6.3-19.6	.363	.258
	Mean (SD)	15.1 (9.5)	16.9 (12.3)	15.5 (10.2)			
	>6.3 n (%)	18 (15.1)	2 (5.9)	20 (13.1)			
	<19.6 n (%)	30 (25.2)	12 (35.3)	42 (27.5)			
Red blood cells (x10^6/μL)	n (%)	117 (78.0)	33 (22.0)	150	6.0-10.1	.194	.454
	Mean (SD)	7.6 (2.1)	7.1 (2.2)	7.5 (2.1)			
	>6 n (%)	21 (17.9)	9 (27.3)	30 (20.0)			
	<10.1 n (%)	11 (9.4)	2 (6.1)	13 (8.7)			
Hemoglobin (g/dL)	n (%)	118 (77.6)	34 (22.4)	152	8.1-14.2	.585	.183
	Mean (SD)	10.7 (2.7)	10.4 (3.4)	10.7 (2.9)			
	>8.1 n (%)	17 (14.4)	9 (26.5)	26 (17.1)			
	<14.2 n (%)	10 (8.5)	4 (11.8)	14 (9.2)			
Hematocrit (%)	n (%)	118 (77.6)	34 (22.4)	152	27.7-46.8	.258	.149
	Mean (SD)	32.4 (8.1)	30.5 (9.4)	32.0 (8.4)			
	>27.7 n (%)	33 (28.0)	14 (41.2)	47 (30.9)			
	<46.8 n (%)	4 (3.4)	0 (0.0)	4 (2.6)			
Mean corpuscular volume (fL)	n (%)	117 (78.0)	33 (22.0)	150	41.3-52.6	.450	.696
	Mean (SD)	42.9 (5.8)	43.8 (7.0)	43.1 (6.1)			
	>41.3 n (%)	47 (40.2)	13 (39.4)	60 (40.0)			
	<52.6 n (%)	6 (5.1)	3 (9.1)	9 (6.0)			
MCHC (g/dL)	n (%)	119 (77.8)	34 (22.2)	153	27.0-32.8	.309	.481
	Mean (SD)	33.5 (3.2)	34.2 (4.5)	33.6 (3.5)			
	>27 n (%)	0 (0.0)	0 (0.0)	0 (0.0)			
	<32.8 n (%)	69 (58.0)	22 (64.7)	91 (59.5)			
RDW (%)	n (%)	104 (77.6)	30 (22.4)	134	14.4-19.4	.532	.610
	Mean (SD)	18.9 (4.5)	18.4 (4.5)	18.8 (4.5)			
	>14.4 n (%)	16 (15.4)	5 (16.7)	21 (15.7)			
	<19.4 n (%)	45 (43.3)	10 (33.3)	55 (41.0)			
Platelets (10^3/μL)	n (%)	91 (79.8)	23 (20.2)	114	156-626	.477	.808
	Mean (SD)	301 (142.0)	326 (163.1)	306 (145.4)			
	>156 n (%)	11 (9.2)	2 (5.9)	13 (8.5)			
	<626 n (%)	3 (2.5)	1 (2.9)	4 (2.6)			
Mean platelet volume (fL)	n (%)	101 (78.3)	28 (21.7)	129	8.6-18.9	.548	.479
	Mean (SD)	15.3 (5.5)	14.6 (5.1)	15.2 (5.4)			
	>8.6 n (%)	5 (5.0%)	2 (7.1)	7 (5.4)			
	<18.9 n (%)	25 (24.8)	4 (14.3)	29 (22.5)			
Neutrophils (x10^3/μL)	n (%)	49 (76.6)	15 (23.4)	64	3.0-13.4	.710	.918
	Median (IQR)	9.5 (5.9-15.6)	11.0 (6.7-21.1)	10.5 (6.0-17.4)			
	>3 n (%)	4 (8.2)	2 (13.3)	6 (9.4)			
	<13.4 n (%)	17 (34.7)	6 (40)	23 (35.9)			
Lymphocytes (10^3/μL)	n (%)	49 (76.6)	15 (23.4)	64	2.0-7.2	.447	.800
	Median (IQR)	1.4 (0.8-2.5)	1.4 (0.9-2.2)	1.5 (1.0-2.4)			
	>2 n (%)	33 (67.3)	11 (73.3)	44 (68.7)			
	<7.2 n (%)	1 (2.0)	1 (6.7)	2 (3.1)			
Monocytes (10^3/μL)	n (%)	49 (76.6)	15 (23.4)	64	0.0-1.0	.612	.779
	Median (IQR)	0.4 (0.2-0.8)	0.3 (0.2-0.5)	0.3 (0.2–0.8)			
	<1 n (%)	8 (16.3)	2 (13.3)	10 (15.6)			
Eosinophils (10^3/μL)	n (%)	49 (76.6)	15 (23.4)	64	0.3-1.7	.454	.227
	Median (IQR)	0.2 (0.05-0.5)	0.1 (0.03-0.5)	0.1 (0.03–0.5)			
	>0.3 n (%)	31 (63.3)	12 (80)	43 (67.2)			
	<1.7 n (%)	0 (0)	0 (0)	0 (0)			

(*Continues*)

TABLE 2 (Continued)

Analyte[a]		Survivors	Nonsurvivors	All cats	Reference interval	*P* value[b]	*P* value[c]
Basophils (10^3/μL)	n (%)	49 (76.6)	15 (23.4)	64	0.0-0.1	.529	.052
	Median (IQR)	0.01 (0.0-0.02)	0.01 (0.0-0.04)	0.01 (0.0-0.2)			
	<0.1 n (%)	0 (0)	2 (13.3)	2 (3.1)			
Prothrombin time (s)	n (%)	23 (69.6)	10 (30.3)	33	8.7-10.5	.754	
	Median (IQR)	16 (12.9-19.1)	15.5 (12.5-19.7)	16 (12.7-19.6)			
	>10.5 n (%)	18 (78.3)	10 (100)	28 (84.8)			.046
aPTT (s)	n (%)	23 (69.6)	10 (30.3)	33	12.3-16.7	.247	
	Median (IQR)	29 (20.8-65.2)	41.3 (31.9-83.3)	35.5 (22.1-67.6)			
	>16.7 n (%)	22 (95.6)	10 (100)	32 (97)			.391

aPTT, activated partial thromboplastin time; IQR, interquartile range; MCHC, Mean corpuscular hemoglobin concentration; RDW, red blood cell distribution width; SD, standard deviation.

[a] Normally and non-normally distributed variables are presented as mean (SD) or median (IQR), respectively. For each variable, the number (%) of cases above and below reference interval are also presented. Only the Advia 120 analyzer differential leukocyte counts were included. When CBC had been performed by the referring veterinarian within a day of hospitalization, the test had not been repeated and available data were used for statistical analyses.

[b] Comparisons of quantitative variables between survivors and nonsurvivors. When the Bonferroni method was employed for correcting for the significance level for 144 comparisons made in this study, the adjusted significance level was .00034, rendering all results statistically insignificant.

[c] The frequencies of cats within, above and below reference intervals were compared between groups by the χ^2 or the Fisher exact tests, and when significant, post hoc pair-wise analyses were made to determine which frequency was significantly different.

Because clinical differentiation often is not feasible, we have included all cats presented with clinical signs and diagnosis of pancreatitis that required hospitalization. This exploratory study did not have predetermined hypotheses, and should be regarded as a hypothesis-generating study. Its results should be considered preliminary, and as such, must be confirmed by further confirmatory studies.

The present findings of signalment, history, physical examination and laboratory tests are characteristic of FP, in agreement with previous reports.[2,11,13,24,28,30,31]At presentation, mean BW, but not BCS, was lower in nonsurvivors, in agreement with the higher frequency of weight loss reported in this group, likely reflecting more severe negative energy balance. In a study of total PN (TPN) in cats, of which almost half had pancreatitis, weight loss was negatively associated with outcome.[32] Lower BCS at presentation and occurrence of weight loss are frequent findings in FP,[11,13,24,28] possibly representing a protracted disease course. Nevertheless, in our study, BW and BCS were only weakly and negatively correlated with duration of clinical signs before presentation. Duration of clinical signs before presentation plays a role in development of a negative energy balance, and results of the multivariable logistic regression analysis suggest the longer the duration, the higher the risk of death.

The occurrence of fever at presentation was unexpectedly more common in survivors. This finding potentially was related to the increased frequency of azotemia in nonsurvivors, which previously has been associated with hypothermia in cats,[33] and the increased frequency of fever in non-azotemic cats. The higher frequency of hypoglycemia and severe lethargy in the nonsurvivors is another possible explanation. Lastly, the occurrence of fever likely prompted antibacterial treatment in all hyperthermic cats,[2,31,34] which was associated with survival in our study.

Contrary to previous reports, leukopenia was not associated with death in our study.[2,31] Neutrophil cytoplasmic toxicity, a common finding in ill hospitalized cats,[35] was documented in almost half of the cats, surpassing in frequency the occurrence of left shift, a reported negative prognostic marker in cats,[35] as well as that of leukocytosis, leukopenia, and neutrophilia.

Increased CK activity, albeit unassociated with survival, was noted frequently in our study. A marker of muscle injury, CK activity was associated with longer hospitalization time and death in a large heterogeneous cohort of ill cats, where pancreatitis constituted 8.5% of the cases, of which 45% had increased CK activity, and recently was associated with death in a study of 71 cats with hepatic lipidosis (HL), of which 24% had concurrent pancreatitis.[36,37] In another study, CK activity was significantly higher in anorectic cats, and was deemed a useful nutritional status marker,[38] as in humans.[39] In our study, lethargy, likely associated with recumbency, anorexia, and weight loss were common and potentially accounted for the increased CK activity.

Previously unreported, higher frequencies of several serum biochemistry abnormalities were documented in nonsurvivors, including higher frequencies of azotemia, hypoglycemia, and low serum TCO_2 concentration. Because serum bicarbonate comprises >90% of serum TCO_2, decreased TCO_2 often is indicative of acidemia and metabolic acidosis.[40,41] Medical conditions resulting in hypoperfusion and anaerobic metabolism often lead to lactic acidosis, the most common cause of metabolic acidosis in cats.[42] Most cats in our study were dehydrated, and concurrent vomiting, diarrhea and anorexia might have resulted in hypovolemia and subsequent hypoperfusion.[42] Furthermore, concurrent hypoglycemia, diabetic ketoacidosis (DKA), and kidney disease, variably present in this cohort, possibly contributed to metabolic acidosis.[42] Although the prognostic relevance of metabolic acidosis is contingent upon its cause and reversibility,[42,43] its association with death in our study likely mirrors disease severity and comorbidities, and also was reported in cats with DKA and in dogs with pancreatitis.[44,45] Accurate characterization of acid-base abnormalities would have necessitated venous blood gas and lactate measurements, which were unavailable in most cats. Future studies, with serial monitoring of acid-base status during hospitalization, may further elucidate the prognostic and therapeutic implications of these findings.

TABLE 3 Serum biochemistry results of 157 cats with pancreatitis at presentation

Analyte[a]		Survivors	Nonsurvivors	All cats	Reference interval	*P* value[b]	*P* value[c]
Albumin (g/dL)	n (%)	116 (77.3)	34 (22.7)	150	2.2-4.6	.151	.260
	Mean (SD)	3.2 (±0.6)	3.0 (±0.7)	3.15 (±0.6)			
	>2.2; n (%)	7 (6.0)	4 (11.8)	11 (7.3)			
	<4.6; n (%)	0 (0.0)	0 (0.0)	0 (0.0)			
Total protein (g/dL)	n (%)	109 (77.3)	32 (22.7)	141	6.6-8.4	.929	.538
	Mean (SD)	7.2 (±1.3)	7.2 (±1.4)	7.2 (±1.3)			
	>6.6; n (%)	37 (33.9)	13 (40.6)	50 (35.5)			
	<8.4; n (%)	19 (17.4)	7 (21.9)	26 (18.4)			
Globulin (g/dL)	n (%)	109 (77.9)	31 (22.1)	140	2.8-5.4	.720	.449
	Median (IQR)	3.9 (3.3-4.6)	3.6 (3.1-4.6)	3.8 (3.2-4.6)			
	>2.8; n (%)	13 (11.9)	4 (12.9)	17 (12.1)			
	<5.4; n (%)	9 (8.3)	5 (16.1)	14 (10.0)			
Total bilirubin (mg/dL)	n (%)	111 (78.2)	31 (21.8)	142	0.0–0.2	.668	.849
	Median (IQR)	0.3 (0.1-1.4)	0.3 (0.1-2.6)	0.3 (0.1-1.9)			
	<0.2; n (%)	63 (56.8)	17 (54.8)	80 (56.3)			
Cholesterol (mg/dL)	n (%)	103 (78.6)	28 (21.4)	131	89-258	.646	.819
	Mean (SD)	177 (±98)	186 (±92)	179 (±96)			
	>89; n (%)	14 (13.6)	3 (10.7)	17 (13.0)			
	< 258; n (%)	18 (17.5)	4 (14.3)	22 (16.8)			
Total CO_2 (mmol/L)	n (%)	73 (77.7)	21 (22.3)	94	15-21	.027	.089
	Median (IQR)	15.8 (12.9–19.1)	14.6 (9.7-16.4)	15.6 (12.0-18.4)			
	>15 n (%)	30 (41.1)	13 (61.9)	43 (45.7)			
	<21 n (%)	11 (15.1)	0 (0.0)	11 (11.7)			
Creatinine (mg/dL)	n (%)	120 (77.4)	35 (22.6)	155	0.6-1.6	.048	
	Median (IQR)	1.4 (1.0–2.4)	1.8 (1.2-6.0)	1.5 (1.0-2.8)			
	>0.6; n (%)	6 (5.0)	1 (2.9)	7 (4.5)			
	<1.6; n (%)	44 (36.6)	21 (60.0)	49 (31.6)			.014
Glucose (mg/dL)	n (%)	112 (77.8)	32 (22.2)	144	63-118	.022	
	Median (IQR)	160 (118-219)	125 (96-161)	149 (112-212)			
	>63; n (%)	2 (1.8)	4 (12.5)	6 (4.2)			.007
	<118; n (%)	84 (75.0)	17 (53.1)	101 (70.1)			.017
Triglycerides (mg/dL)	n (%)	83 (79.8)	21 (20.2)	104	8–80	.862	.802
	Median (IQR)	92 (46-186)	86 (34-297)	91 (44-253)			
	< 80; n (%)	46 (55.4)	11 (52.4)	57 (54.8)			
Total calcium (mg/dL)	n (%)	107 (78.1)	30 (21.9)	137	9.0-10.9	.601	.765
	Mean (SD)	9.4 (±1.3)	9.3 (±1.2)	9.3 (±1.3)			
	> 9.0; n (%)	42 (39.3)	11 (36.7)	53 (38.7)			
	<10.9; n (%)	11 (10.3)	2 (6.7)	13 (9.5)			
Free (ionized) calcium[d] (mmol/L)	n (%)	66 (78.6)	18 (21.4)	84	0.8-1.4	.396	
	Mean (SD)	1.1 (±0.2)	1.0 (±0.2)	1.1 (±0.2)			
	>0.8; n (%)	3 (4.5)	4 (22.2)	7 (8.3)			.016
	< 1.4; n (%)	2 (3.0)	0 (0.0)	2 (0.02)			1.000
Urea (mg/dL)	n (%)	112 (76.7)	34 (23.3)	146	38.5-70.6	.252	.523
	Median (IQR)	55 (39-125)	75.3 (45-164)	62 (39-130)			
	>38.5; n (%)	27 (24.1)	7 (20.6)	34 (23.3)			
	<70.6 n (%)	47 (42.0)	18 (52.9)	65 (44.5)			
BHBA (mmol/L)	n (%)	43 (79.6)	11 (20.4)	54	0.0-0.47	.957	.940
	Median (IQR)	0.37 (0.1-0.9)	0.32 (0.1-0.7)	0.37 (0.1-1.0)			
	<0.47 n (%)	19 (44.2)	5 (45.5)	24 (44.4)			

(*Continues*)

TABLE 3 (Continued)

Analyte[a]		Survivors	Nonsurvivors	All cats	Reference interval	*P* value[b]	*P* value[c]
Phosphorus (mg/dL)	n (%)	113 (77.4)	33 (22.6)	146	3.2-6.3	.067	.138
	Median (IQR)	4.7 (3.7-7.1)	5.5 (4.0-8.8)	4.8 (3.7-7.7)			
	>3.2; n (%)	10 (8.8)	0 (0.0)	10 (6.8)			
	<6.3; n (%)	32 (28.3%)	13 (39.4)	45 (30.8)			

BHBA, beta hydroxybutyric acid; IQR, interquartile range; SD, standard deviation.
[a] Normally and non-normally distributed variables are presented as mean (SD) or median (IQR), respectively. For each variable, the number (%) of cases above and below reference interval are also presented.
[b] Comparisons of quantitative variables between survivors and nonsurvivors. When the Bonferroni method was employed for correcting for the significance level for 144 comparisons made in this study, the adjusted significance level was .00034, rendering all results statistically insignificant.
[c] The frequencies of cats within, above and below reference intervals were compared between groups by the χ^2 or the Fisher exact tests, and when significant, post hoc pair-wise analyses were made to determine which frequency was significantly different.
[d] Free (ionized) calcium was measured in 58/84 cats, at presentation, and in 26/84, later during hospitalization.

Ionized hypocalcemia was more frequent in nonsurvivors compared to survivors, in accordance with previous findings.[24,46] A known complication of both AKI and AP, it might have contributed to the increased frequency of lethargy in nonsurvivors, and contributed to seizures in 1 cat.

Azotemia was more frequent in nonsurvivors. Pancreatitis and AKI are common comorbidities in humans and dogs, each can potentially precipitate the other.[47–49] Azotemia at presentation and development of AKI also are associated with worse prognosis in other diseases of cats,[44,50] especially as AKI itself carries a guarded prognosis.[51]

Hypoglycemia occurs in cats with AP and CP,[11] and was reported previously in 3/4 ASP cases.[13] Its high frequency, particularly in AP and ASP, may account for its higher frequency in nonsurvivors and its association with death when assessed by a multivariable logistic regression in our study. Pancreatitis-induced hypoglycemia may result from concurrent sepsis or liver failure (eg, HL), anorexia, and decreased hepatic glycogen reserves. Bacterial infection is a suspected cause of ASP, potentially resulting in sepsis-induced hypoglycemia[13] (Simpson and coworkers. Culture-independent detection of bacteria in feline pancreatitis. In: 21st ACVIM Forum, Denver, Colorado, June 15-18, 2011). Additionally, in human patients with concurrent DM and CP, glucagon response to hypoglycemia is impaired, predisposing to insulin-induced hypoglycemic crises.[52,53] Diabetic cats with ANP show a marked response to insulin administration.[13] Inadequate pancreatic glucagon secretion also may account for pancreatitis-induced hypoglycemia in cats, warranting further studies.

Clotting times (PT and aPTT), measured in only 33 cats, were almost invariably prolonged. Hemostatic derangements in FP are poorly defined. In 1 study, median clotting times were within RI in both ANP and CP,[11] whereas in another, both were prolonged in all cats with concurrent HL and AP, but only in 2/6 HL cases in which concurrent AP was absent.[54] In a study of DIC in cats, FP accounted for 12/46 cases.[23] Overt bleeding was not observed in any of the cats in our study, despite the high frequency of hemostatic abnormalities.

Evidence-based treatment recommendations for FP are lacking. Treatment guidelines largely rely on experience in human patients, circumstantial evidence and expert opinion.[2,31] We have identified 2 salient treatment-related variables that differed between the 2 outcome groups. First, PN was more commonly administered in nonsurvivors, whether as sole nutritional support or as ancillary treatment to enteral feeding. It is impossible to retrospectively determine whether PN treatment merely reflects a selection bias associated with more severe and prolonged disease (ie, PN was administered to cats too unstable to undergo general anesthesia for feeding tube placement or cats with persistent anorexia during hospitalization), or independently imparts a worse prognosis. In a retrospective study of TPN in cats, of which 46% had pancreatitis, the mortality rate was 52%.[32] In humans with AP, withholding food is no longer recommended, and PN alone has been shown to compromise intestinal barrier integrity, increasing the risk of bacterial translocation and promoting mucosal atrophy and proinflammatory responses.[32,55] In our study, multivariable logistic regression showed that failure to eat voluntarily during hospitalization was a significant risk factor for death. Ultimately, the sequelae of PN increase morbidity and mortality, possibly accounting for our findings. Second, antibiotic treatment was more commonly withheld in nonsurvivors compared to survivors. Scientific reviews of FP espouse the notion that antibacterial treatment should be reserved for severe cases, such as those presenting with shock, fever, marked leukocytosis, or pancreatic abscessation.[2,31,34] This notion is based on experimental FP models, histological and molecular findings suggestive of bacterial involvement, and drawing parallels between cats and humans with pancreatitis. In a series of studies in cats, experimentally-induced pancreatitis enhanced colon-derived *Escherichia coli* pancreatic colonization, and facilitated pancreatic colonization by exogenous *E. coli*, administered by IV, transcolonic, or pancreatic ductular routes.[56,57] The latter was prevented by prophylactic cefotaxime administration.[58] Florescence in situ hybridization has identified bacteria in 35% of pancreatic samples from cats with moderate to severe pancreatitis, but in only 1 healthy control cat (Simpson and coworkers. Culture-independent detection of bacteria in feline pancreatitis. In: 21st ACVIM Forum, Denver, Colorado, June 15-18, 2011). Employing a similar method, intrahepatic bacteria were noted in 41% of cats with inflammatory liver disease,[59] which is clinically relevant, because hepatic and pancreatic inflammations are common comorbidities in cats, because their collecting ducts join anatomically before entering the duodenum.[12,18,31] Moreover, pancreatic intra-ductular neutrophilic inflammation and presence of bacteria, albeit rarely reported, are suggestive of ascending infection in some cases,[1,13] in addition to suspected hematogenous spread in inflammatory hepato-billiary diseases.[59] Secondary bacterial infection is a common cause of morbidity and mortality in humans with AP.[55] Prophylactic antibiotic treatment, however, is controversial, with conflicting data to support this practice.[55] Prospective randomized studies are warranted to clarify the role of antibiotic treatment in FP, particularly in light of the limited number of cats in our study in which antibiotic treatment was withheld.

Published mortality rates in FP are scarce, and vary widely among studies,[24–26] owing to the paucity of observational studies and wide

TABLE 4 Serum enzyme activities and electrolyte concentrations of 157 cats with pancreatitis at presentation

Analyte[a]		Survivors	Nonsurvivors	All cats	Reference interval	*P* value[b]	*P* value[c]
Alkaline phosphatase (U/L)	n (%)	114 (78.6)	31 (21.4)	145	14-71	.347	
	Median (IQR)	26 (16-75)	31 (16-84)	29 (16-75)			
	<71 n (%)	30 (26.3)	8 (25.8)	38 (26.1)			.954
Alanine transaminase (U/L)	n (%)	114 (78.1)	32 (21.9)	146	27-101	.766	
	Median (IQR)	77 (49-173)	89 (48-262)	80 (49-200)			
	<101 n (%)	47 (41.2)	14 (43.8)	61 (41.8)			.798
Amylase (U/L)	n (%)	109 (79.0)	29 (21.)	138	500-1900	.104	
	Median (IQR)	1038 (728-1440)	1267 (878-2216)	1078 (753-1470)			
	<1800 n (%)	15 (13.8)	9 (31.0)	24 (17.4)			.029
Aspartate transaminase (U/L)	n (%)	95 (79.8)	24 (20.2)	119	17-58	.706	
	Median (IQR)	62 (36-110)	70 (30–192)	62.4 (34-140)			
	<58 n (%)	50 (52.6)	12 (50.0)	62 (52.1)			.817
Creatine kinase (U/L)	n (%)	84 (80.0)	21 (20.0)	105	73-260	.344	
	Median (IQR)	303 (146-829)	509 (190-1071)	323 (151-913)			
	<260 n (%)	49 (58.3)	13 (61.9)	62 (59.0)			.765
γ-Glutamyl transpeptidase (U/L)	n (%)	94 (77.7)	27 (22.3)	121	0–4	.920	
	Median (IQR)	0.0 (0.0-1.2)	0.0 (0.0-3.6)	0.0 (0.0-1.5)			
	<4 n (%)	11 (11.7)	5 (18.5)	16 (13.2)			.357
Chloride (mmol/L)	n (%)	102 (77.3)	30 (22.7)	132	117-126	.454	
	Median (IQR)	113 (107-118)	114 (109-118)	113 (108-118)			
	>117 n (%)	71 (69.6)	20 (66.7)	91 (68.9)			.678
	<126 n (%)	3 (2.9)	2 (6.7)	5 (3.8)			
Potassium (mmol/L)	n (%)	114 (77.6)	33 (22.4)	147	3.6-4.9	.376	
	Median (IQR)	4.3 (3.7-4.8)	4.1 (3.6-4.6)	4.3 (3.6-4.8)			
	>3.6 n (%)	24 (21.1)	7 (21.2)	31 (21.1)			.750
	<4.9 n (%)	20 (17.5)	4 (12.1)	24 (16.3)			
Sodium (mmol/L)	n (%)	107 (77.0)	32 (23.0)	139	151-158	.986	
	Mean (SD)	146 (±8.5)	146 (±9.9)	146 (±8.8)			
	>151 n (%)	82 (76.6)	22 (68.8)	104 (74.8)			.565
	<158 n (%)	3 (2.8)	2 (6.3)	5 (3.6)			

IQR, interquartile range; SD, standard deviation.

[a] Normally and non-normally distributed variables are presented as mean (SD) or median (IQR), respectively. For each variable, the number (%) of cases above and below reference interval are also presented.

[b] Comparisons of quantitative variables between survivors and nonsurvivors. When the Bonferroni method was employed for correcting for the significance level for 144 comparisons made in this study, the adjusted significance level was .00034, rendering all results statistically insignificant.

[c] The frequencies of cats within, above and below reference intervals were compared between groups by the χ^2 or the Fisher exact tests, and when significant, post hoc pair-wise analyses were made to determine which frequency was significantly different.

heterogeneity in etiology and histopathological classification, as well as the variable occurrence of comorbidities.[14,16,18,54,60] In our study, without distinction between AP and CP, the overall mortality rate was approximately 22%.

Our study had several limitations. First, data were retrospectively retrieved, and medical records occasionally were incomplete, thereby weakening some statistical analyses, which also were hampered when small groups were compared. Certain laboratory tests (ie, hemostatic tests) were available only in a small number of cats.

Second, owing to study design, bias may have decreased the validity of some findings, such as the association between PN and outcome, and a cause and effect relationship cannot be necessarily concluded. Our relatively limited cohort size, with respect to the large number of variables, only enabled us to identify potential prognostic factors, which statistically differed between survivors and nonsurvivors, and the relatively low number of deaths (n = 35) and missing data (ie, iCa only was available in 84 cats) rendered the multivariable logistic regression analyses underpowered. Furthermore, employing the conservative Boneferroni method for adjusting the significance level for multiple comparisons rendered all individual comparisons insignificant, despite the relatively large cohort. However, as stated above, our study was an exploratory one, and had no pre-specified hypotheses, in which large amount of data with multiple comparisons were analyzed. The use of multiplicity adjustment in such studies engenders loss of power, and substantially increases the type II error rate, while eliminating the chances of type I errors.[61] Thus, many factors of potential clinical relevance may have been overlooked. We therefore elected to present our exploratory results, which must be subsequently tested in confirmatory, hypothesis-driven studies.[61]

Third, in some cats, pancreatitis was diagnosed by ultrasonography, along with compatible clinical and laboratory findings, whereas in other cats, histopathology or pancreatic-specific lipases were used.

TABLE 5 Comorbidities and complications in 157 hospitalized cats with pancreatitis

Disease or condition	Survivors (n = 122) n (%)	Nonsurvivors (n = 35) n (%)	All cats (n = 157) n (%)	*P* value[a]
Chronic kidney disease	36 (29.5)	13 (37.1)	52 (34.0)	.390
Acute kidney injury	28 (23.0)	14 (40.0)	42 (26.8)	.045
Diabetes mellitus[b]	17 (13.9)	4 (11.4)	21 (13.4)	.701
Cardiac disease (general)	16 (13.1)	6 (17.6)	22 (14.1)	.564
Hepatic lipidosis	15 (12.3)	4 (11.4)	19 (12.1)	.890
Pleural effusion	9 (7.6)	9 (25.7)	18 (11.7)	.003
Diabetic ketoacidosis	14 (11.5)	1 (2.9)	15 (9.6)	.126
Inflammatory bowel disease	8 (6.6)	3 (8.6)	11 (7.0)	.681
Feline immunodeficiency virus infection	6 (28.6)	3 (75.0)	9 (36.0)	.081
Neoplasia (general)	5 (4.1)	1 (2.9)	6 (3.8)	.727
Disseminated intravascular coagulation	3 (2.5)	2 (5.7)	5 (3.2)	.309
Immune mediated hemolytic anemia	3 (2.5)	0 (0)	3 (1.9)	1
Pneumonia	3 (2.5)	0 (0)	3 (1.9)	1

[a] When the Bonferroni method was employed for correcting for the significance level for 144 comparisons made in this study, the adjusted significance level was .00034, rendering all results statistically insignificant.
[b] Including cats with diabetic ketoacidosis.

Admittedly, a definitive diagnosis of FP is not commonly achieved, because procurement of biopsy samples for histopathology is seldom carried out in most clinical settings.[2,31] Although abdominal sonography lacks sensitivity (ranging from 11% to 84%, depending on disease severity, ultrasound technology and the radiologist's expertise), it is fairly specific for diagnosing pancreatitis.[2,6–8,19,28,31] Moreover, when the accuracy of sonography for detecting pancreatitis is assessed against pancreatic-specific lipase assays, specificity may spuriously decrease, because these assays are relatively insensitive in mild to moderate disease.[5,7] Therefore, despite its inherent limitations, ultrasonographically-confirmed cases are commonly recruited.[2,24,26,62] In addition, 16 cats were diagnosed by positive SNAP fPLI, which indicates both equivocal (3.6-5.3 μg/L) and true positive (>5.3 μg/L) cases,[4] and therefore the proportion of false positives in this group could not be determined in the absence of further investigations. Moreover, in this subgroup of cats, the proportion of nonsurvivors was significantly higher (8/16 cats), which may have led to spurious overestimation of the overall nonsurvivor rate.

Fourth, for some cases the occurrence of co-morbidities (eg, IBD, cholangiohepatitis) could not have been excluded without histopathology, which was unavailable in most cases.

Finally, our study was conducted in a single, tertiary veterinary teaching hospital, and its results should be applied cautiously to other clinical settings.

In conclusion, several important variables, of clinical and therapeutic relevance (eg, hypoglycemia, ionized hypocalcemia, azotemia, antibacterial use and PN) were identified that differed between survivors and nonsurvivors in cats with AP. Prospective, controlled studies are required to examine the validity of these findings.

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CONFLICT OF INTEREST DECLARATION

Authors declare no conflict of interest.

OFF-LABEL ANTIMICROBIAL DECLARATION

Authors declare no off-label use of antimicrobials.

INSTITUTIONAL ANIMAL CARE AND USE COMMITTEE (IACUC) OR OTHER APPROVAL DECLARATION

Authors declare no IACUC or other approval was needed.

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