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Complete Blood Count as a Screening Tool for Pancreatitis in Lethargic and Anorectic Cats

Daniela Ionescu[1]*, Vlad Petrescu[1]

[1]Department of Veterinary Clinical Sciences, Faculty of Veterinary Medicine, University of Bucharest, Bucharest, Romania.

***E-mail** ✉ d.ionescu.vet@outlook.com

ABSTRACT

Feline pancreatitis (FP) represents a significant clinical challenge in cats. Current gold-standard diagnosis relies on the combination of serum feline pancreatic lipase immunoreactivity (fPLI) measurement and abdominal ultrasonography (AUS). Although these methods provide high specificity, they are costly and require considerable time. A rapid, inexpensive screening tool with high sensitivity capable of reliably excluding FP during the initial consultation would therefore be highly valuable. To assess the diagnostic performance of routine complete blood count (CBC)-derived inflammatory parameters for detecting FP, 73 client-owned cats presenting with lethargy and reduced appetite for ≥2 days were prospectively enrolled. Cats were categorized as very low risk for FP if fPLI ≤3.5 µg/L and AUS negative, or as increased risk for FP with any other result combination. Seven CBC parameters were then evaluated for association with FP risk using multivariable logistic regression. Five CBC parameters showed significant association with increased FP risk: total leukocyte count (WBC; crude OR = 12.2; 95% CI: 1.52–98.5), total neutrophil count (crude OR = 5.84; 95% CI: 1.22–27.9), band neutrophil count (BNC; crude OR = 6.67; 95% CI: 1.98–22.4), neutrophil-to-lymphocyte ratio (crude OR = 3.68; 95% CI: 1.25–10.9), and eosinophil count (EC; crude OR = 0.34; 95% CI: 0.12–0.96). A diagnostic model incorporating WBC, BNC, and EC demonstrated at least fair accuracy (AUC = 82.7%; 95% CI: 72.8–92.5%). Defining a negative test as WBC < 18 G/L, BNC < 0.27 G/L, and EC > 0.3 G/L (any other combination = positive) yielded high sensitivity (91.8%; 95% CI: 80.8–96.8%) with moderate specificity (58.3%; 95% CI: 38.8–75.5%). A simple combination of three routine CBC parameters offers an immediately available, cost-effective screening tool to identify cats with lethargy and anorexia that are at elevated risk of FP.

Keywords: Abdominal ultrasonography, Band neutrophil count, Eosinophil count, Feline pancreatic lipase immunoreactivity, fPLI, Neutrophil-to-lymphocyte ratio, White blood cell count

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Background

Feline pancreatitis (FP) is a frequent disorder in cats, typically of unknown etiology, with nonspecific clinical signs, challenging and expensive diagnostic workup, and uncertain prognosis [1–5]. The most common owner-reported complaints are lethargy and inappetence/anorexia, followed by vomiting, weight loss, and occasionally diarrhea [5]. Histopathologically, FP is classified into acute necrotizing, acute suppurative, and chronic forms [6, 7], but these entities are clinically indistinguishable in practice [8], so the umbrella term “feline pancreatitis” is widely accepted [5].

Currently, the cornerstone of FP diagnosis remains the combined use of serum pancreatic lipase immunoreactivity (fPLI), or the DGGR lipase activity assay, together with abdominal ultrasonography (AUS) [2, 3, 5, 9]. Reported diagnostic sensitivity and specificity vary widely: fPLI 50–80% and 50–100% [10–14], AUS 25–80% and 70–90% [10, 15, 16], depending on chosen cut-offs (fPLI 3.5 or 5.3 µg/L; number of ultrasonographic criteria), disease severity, and operator/ultrasound equipment quality. Most studies agree that specificity generally exceeds sensitivity [2, 3, 17], meaning positive results are more reliable than negative ones unless pretest probability is very low. Consequently, these tests function better as confirmatory rather than screening tools. An inexpensive, rapidly available screening test with high sensitivity to quickly flag cats at higher risk of FP would therefore be clinically advantageous.

In human and veterinary medicine, various CBC-derived inflammatory markers (total and differential leukocyte counts, neutrophil-to-lymphocyte ratio [NLR], etc.) are routinely used as low-cost indicators to include or exclude active inflammation, infection, or neoplasia [18–23]. Recent work has also associated NLR with presence or severity of feline pancreatitis [22].

The aim of the present study was to determine the diagnostic accuracy of selected CBC parameters as a first-line screening method to identify cats presenting with lethargy and reduced appetite that are at increased risk of FP.

Results

The investigation involved 73 neutered adult cats: 45 males (61.6%) and 28 females (38.4%), ranging in age from 2 to 18 years, median (IQR) 10 (8–12) years. No age difference existed between males and females (p = 0.750). Domestic shorthair cats accounted for 58 animals (79.5%); the remainder comprised Siberian (n = 5, 6.9%), British shorthair (n = 3, 4.1%), Maine Coon, Russian, and Devon Rex (n = 2 each, 2.7%), and one Siamese (1.4%).

Serum fPLI remained ≤3.5 µg/L in 33 cats (45.2%) and exceeded 3.5 µg/L in 40 cats (54.8%), with 8 cases between 3.6–5.3 µg/L and 32 cases >5.3 µg/L. Ultrasound detected at least one pancreatic abnormality in 26 cats (35.6%). Using the combined reference standard, 24 cats (32.9%) were placed in the very-low-risk group (fPLI ≤3.5 µg/L plus normal pancreatic ultrasound), while 49 cats (67.1%) were assigned to the increased-risk group (fPLI >3.5 µg/L and/or pancreatic ultrasound abnormalities). Of the 49 increased-risk cats, only 17 (34.7%) showed both abnormalities; 23 (46.9%) had isolated fPLI elevation and 9 (18.4%) had isolated ultrasound changes.

Comorbidities included diabetes mellitus in 29 cats (39.7%), presumptive liver disease in 22 (30.1%; ALT median (range) 307 (58–2322) U/L; total bilirubin 18.8 (6.8–359.1) µmol/L), presumptive acute kidney injury in 7 (9.6%; urea 29.0 (17.9–62.7) mmol/L, creatinine 353.6 (256.4–1246) µmol/L), and neoplasia in 3 (4.1%) (one each hepatic carcinoma, intestinal lymphoma, pulmonary metastases from mammary carcinoma). Dehydration/hemoconcentration occurred in 23 cats (31.5%; Ht 0.38 (0.16–0.51) L/L, total protein 73 (52–97) g/L, urea 19.9 (9.1–97.2) mmol/L, creatinine 168 (97.2–256.4) µmol/L); anemia was noted in 10 cats (13.7%; Ht 0.24 (0.16–0.26) L/L). Owners reported vomiting in 37 cats (50.7%) and diarrhea in 9 (12.3%). Clinicians recorded abdominal pain in 13 cats (17.8%) and fever in 3 (4.1%). Increased-risk cats were older (p = 0.038); no other variables differed between risk groups **(Table 1)**.

Table 1. Demographic and clinical characteristics of the study cats

Characteristic	P-value[b]	Increased risk of feline pancreatitis (n = 49)	Very low risk of feline pancreatitis (n = 24)
Demographic characteristics			
Age [years] – median, IQR (range)	0.038*	11, 9–13 (2–18)	10, 7–11 (2–15)
Sex – males, n (%)	0.685[c]	31 (63.3)	14 (58.3)
Breed – domestic shorthair, n (%)	0.218	12 (24.5)	3 (12.5)
Comorbidities			
Diabetes mellitus, n (%)	0.785	20 (40.8)	9 (37.5)
Suspected hepatopathy, n (%)	0.216	17 (34.7)	5 (20.8)
Suspected acute kidney injury, n (%)	0.999[d]	5 (10.2)	2 (8.3)
Anemia, n (%)	0.481[d]	8 (16.3)	2 (8.3)
Hemoconcentration, n (%)	0.397	17 (34.7)	6 (25.0)
Hyperthyroidism, n (%)	0.319[d]	0	1 (4.2)
Neoplastic disease, n (%)	0.546[d]	3 (6.1)	0
Clinical signs			
Vomiting, n (%)	0.113	28 (57.1)	9 (37.5)
Diarrhea, n (%)	0.051[d]	3 (6.1)	6 (25.0)

Abdominal pain, n (%)	0.407	10 (20.4)	3 (12.5)
Fever, n (%)	0.546[d]	3 (6.1)	0

*Significant at α = 0.05
[a]Presented as n(%) unless otherwise stated
[b]Maximum likelihood G-test unless otherwise stated
[c]Mann-Whitney U test
[d]Fisher exact test

Unadjusted analysis revealed five CBC variables linked to higher FP risk: WBC, total neutrophil count (TNC), band neutrophil count (BNC), and NLR (all positive associations) plus eosinophil count (EC; inverse association) **(Table 2)**.

Table 2. Unadjusted associations between categorized CBC variables and increased risk of feline pancreatitis

CBC-based inflammatory biomarker	Category	Cats with increased FP risk / total cats in category (%)	Crude odds ratio (ORcrude) (95% CI)	P-value[a]
Total leukocyte count [G/L]	≥ 18 (n = 18)	17 / 18 (94.4)	12.2 (1.52–98.5)	0.002*
	< 18 (n = 55)	32 / 55 (58.2)		
Total neutrophil count [G/L]	≥ 15 (n = 19)	17 / 19 (89.5)	5.84 (1.22–27.9)	0.010*
	< 15 (n = 54)	32 / 54 (59.3)		
Band neutrophil count [G/L]	≥ 0.27 (n = 32)	28 / 32 (87.5)	6.67 (1.98–22.4)	0.001*
	< 0.27 (n = 41)	21 / 41 (51.2)		
Lymphocyte count [G/L]	≥ 2.2 (n = 36)	21 / 36 (58.3)	0.45 (0.17–1.23)	0.113
	< 2.2 (n = 37)	28 / 37 (75.6)		
Eosinophil count [G/L]	> 0.3 (n = 36)	20 / 36 (55.6)	0.34 (0.12–0.96)	0.037*
	≤ 0.3 (n = 37)	29 / 37 (78.4)		
Monocyte count [G/L]	≥ 0.15 (n = 12)	11 / 12 (91.6)	6.95 (0.84–57.3)	0.089
	< 0.15 (n = 61)	38 / 61 (62.3)		
Neutrophil-to-lymphocyte ratio [1/1]	≥ 4.7 (n = 33)	27 / 33 (81.8)	3.68 (1.25–10.9)	0.013*
	< 4.7 (n = 40)	22 / 40 (55.0)		

*Significant at α = 0.05
aMaximum likelihood G-test

After adjustment, three variables retained independent predictive value **(Table 3)**: WBC ≥18 G/L (adjusted OR ≈13), BNC ≥0.27 G/L (adjusted OR ≈5), and EC >0.3 G/L (adjusted OR ≈0.25, protective). The resulting three-variable model (CBC model) displayed adequate calibration (Hosmer–Lemeshow χ^2 = 3.04, p = 0.551) and explained variance (Nagelkerke R^2 = 0.40).

Table 3. Final multivariable logistic regression model using CBC parameters to detect elevated pancreatitis risk in cats with lethargy and inappetence

CBC measurements	Regression coefficient (SE)	OR_{adj} (CI 95%)	*P*-value	Wald's statistics
Intercept	0.52 (0.46)	–	–	–
WBC ≥ 18 G/L	2.59 (1.12)	13.3 (1.47, 121)	0.021	5.32
BNC ≥ 0.27 G/L	1.59 (0.67)	4.88 (1.31, 18.2)	0.018	5.56
EC > 0.3 G/L	−1.49 (0.61)	0.23 (0.07, 0.74)	0.014	5.98

BNC Band neutrophil count, CI 95% 95% confidence interval, EC Eosinophil count [G/L], ORadj Adjusted odds ratio, SE Standard error, WBC Total leukocyte count [G/L]
Discrimination of the CBC model was acceptable (AUROC = 82.7%; 95% CI 72.8–92.5%; p < 0.001) and clearly superior to any individual variable **(Figure 1)**: ΔAUROC vs. WBC 24.8% (95% CI 10.9–38.7%, p = 0.001), vs. BNC 11.0% (95% CI 1.6–20.4%, p = 0.022), vs. EC 22.0% (95% CI 7.4–36.3%, p = 0.003).

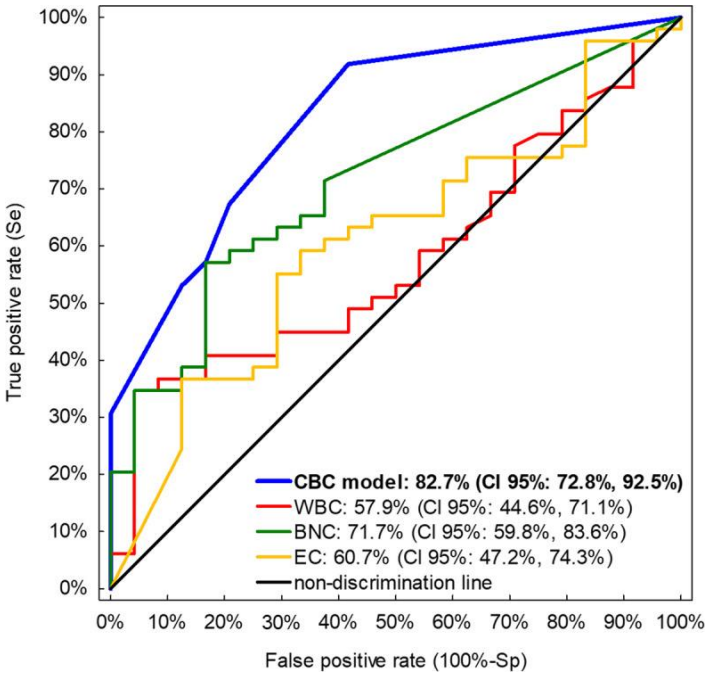

Figure 1. Receiver operating characteristic curves for the three-variable CBC model and the individual parameters (WBC, BNC, EC), with AUROC and 95% CI displayed

When the threshold was set so that a negative result required WBC <18 G/L AND BNC <0.27 G/L AND EC >0.3 G/L (probability cut-off ≥0.628), the model delivered sensitivity 91.8% (95% CI 80.8–96.8%), specificity 58.3% (95% CI 38.8–75.5%), LR+ 2.2 (95% CI 1.4–3.6), and LR− 0.14 (95% CI 0.05–0.38). Performance across alternative decision rules is detailed in **Table 4**.

Table 4. Diagnostic performance of the CBC model using different combinations of the three parameters as decision thresholds. The rule with the highest Youden index (WBC <18 G/L, BNC <0.27 G/L, EC >0.3 G/L = negative) is highlighted; all other combinations are interpreted as positive

Combination of CBC criteria met			CBC model outcome	Accuracy measures
WBC ≥ 18	BNC ≥ 0.27	EC > 0.3		Se (95% CI) Sp (95% CI) LR+ (95% CI) LR- (95% CI) Youden's J (95% CI)
No	No	Yes	0.275	– – – – –
No	No	No	0.628	91.8 (80.8–96.8) 58.3 (38.8–75.5) 2.2 (1.4–3.6) 0.14 (0.05–0.38) 50.2 (39.4–61.0)
No	Yes	Yes	0.649	67.3 (53.4–78.8) 79.2 (59.5–90.8) 3.2 (1.4–7.2) 0.41 (0.26–0.65) 46.5 (35.9–57.2)
Yes	No	Yes	0.835	57.1 (43.3–70.0) 83.3 (64.1–93.3) 3.4 (1.4–8.7) 0.51 (0.36–0.74) 40.5 (30.1–50.9)
No	Yes	No	0.892	53.1 (39.4–66.3) 87.5 (69.0–95.7) 4.2 (1.4–12.6) 0.54 (0.38–0.75) 40.6 (30.7–50.4)
Yes	No	No	0.957	30.6 (19.5–44.5) 100 (86.2–100) +∞ 0.69 (0.58–0.84) 30.6 (24.0–37.2)
Yes	Yes	Yes	0.961	24.5 (14.6–38.1) 100 (86.2–100) +∞ 0.76 (0.64–0.89) 24.5 (18.3–30.6)
Yes	Yes	No	0.991	6.1 (2.1–16.5) 100 (86.2–100) +∞ 0.94 (0.87–1.01) 6.1 (2.7–9.5)

BNC Band neutrophil count [G/L], CI 95% 95% confidence interval, EC Eosinophil count [G/L], J Youden's index [%], LR+ Likelihood ratio of a positive result [1/1], LR- Likelihood ratio of a negative result [1/1], Se Diagnostic sensitivity [%], Sp Diagnostic specificity [%], WBC Total leukocyte count [G/L]

Discussion

We constructed a simple three-parameter logistic regression tool (the CBC model) that achieves at least acceptable diagnostic discrimination (lower 95% CI limit for AUROC >70%) for separating cats with lethargy and anorexia into very-low-risk versus increased-risk groups for FP. This tool offers two major practical advantages. First, it relies exclusively on routine hematology variables (total leukocyte count (WBC), band neutrophil count (BNC), and eosinophil count (EC)) that are almost universally performed in sick cats and are typically reported within hours by any veterinary laboratory. Second, each variable is used only as a binary yes/no decision based on statistically optimized cut-offs derived from Youden's index [24, 25]. With three dichotomous inputs, only $2^3 = 8$ possible patterns exist, so no calculations or software are required at the bedside; the clinician simply checks whether each parameter is above or below its threshold **(Table 4)**.

The three selected leukocyte populations reflect classic acute-phase leukogram alterations: leukocytosis, left shift, and eosinopenia [26–28]. Cats readily develop neutrophilia because their marginal neutrophil pool is approximately three times larger than the circulating pool [26, 27, 29]. Band neutrophils appear in circulation only when tissue demand has been sustained long enough to deplete mature reserves [26, 29], which aligns with our inclusion criterion of clinical signs present for ≥2 days and explains the strong predictive weight of BNC. This left-shift signal might be weaker in cats examined within hours of symptom onset. In many species, acute inflammation typically produces simultaneous neutrophilia and lymphopenia [30]; however, cats frequently show concurrent neutrophilia and lymphocytosis, especially when physiologic excitement from handling or venipuncture is superimposed [26, 29, 31]. Marked lymphocytosis is a hallmark of the feline stress leukogram [26, 29, 31]. This species-specific pattern likely explains why lymphopenia was not retained in the final model and why the neutrophil-to-lymphocyte ratio (NLR)—a marker that performs well in humans [32] and to a lesser degree in dogs [19, 20]—was outperformed by total WBC alone in our population.

The primary goal was to create an inexpensive, instantly available rule-out test rather than a definitive confirmatory tool. CBC parameters are nonspecific markers of systemic inflammation and cannot be expected to match the accuracy of pancreas-specific diagnostics. Their value lies in rapid exclusion of FP when the result is negative. At the optimal decision rule, sensitivity reached approximately 90% (lower 95% CI ≥80%). However, negative predictive value depends heavily on pretest probability, so likelihood ratios provide a more robust interpretation [25]. The negative likelihood ratio (LR−) of the CBC model was approximately 0.14, meaning a negative result is about 7 times more common in cats without FP than in cats with FP. Conventionally, an LR− ≤0.1 is considered strong evidence for ruling out disease [33]; our model falls short of that stringent benchmark. For comparison, the widely used DGGR-lipase assay at its standard cut-off of 26 U/L yields an LR− of approximately 0.4 [13], yet remains a routine screening test. Using Fagan's nomogram [35, 36] or odds conversion [33, 34], an LR− of 0.14–0.2 typically reduces a moderate pretest probability (e.g., 30%) to a post-test probability of roughly 6–10%. Conservatively applying the upper 95% CI of LR− (≈0.38) to a 30% pretest risk yields a post-test probability around 15%. Whether this reduction justifies clinical reliance on a negative CBC model will vary by clinician, but the marginal cost is zero once a CBC has already been performed.

Conversely, extreme positive combinations (e.g., WBC ≥18 G/L + BNC ≥0.27 G/L + EC ≤0.3 G/L) do not confirm FP. Even in our increased-risk reference group (n = 49), many cats had only one abnormal specific test (fPLI or ultrasound), so true disease prevalence was considerably lower than 100%. A strongly positive CBC model therefore indicates an ongoing acute inflammatory response that co-occurs with evidence of possible pancreatic involvement, but numerous differential diagnoses remain plausible. Such cases still warrant targeted FP diagnostics (fPLI ± ultrasound), whereas a negative CBC model can reasonably downgrade FP on the initial differential list in a lethargic, anorectic cat.

The previously discussed constraint regarding the validity of positive CBC model outcomes stems from the principle that diagnostic accuracy metrics are meaningful only when calculated in a cohort of animals whose actual disease status has been reliably established [25, 37]. In the present work, feline pancreatitis (FP) was diagnosed using two separate reference tests applied in parallel: serum fPLI (positive ≥ 3.5 µg/L) and abdominal ultrasonography (AUS; positive if ≥ 1 typical feature of FP was present). Since prior studies have demonstrated only modest agreement between fPLI and AUS [38, 39], we needed a strategy for resolving discordant results. The challenge of classifying subjects when an impeccable gold standard is unavailable has been extensively addressed [40]. Although numerous statistical methods exist, they ultimately require assignment of every animal to either the diseased or non-diseased category, because accuracy assessment demands binary classification. Excluding animals with discrepant test results, however, would generate two highly polarized subgroups with an artificial spectrum bias, differing not solely in true FP status but also in overall severity and numerous uncontrolled

variables, thereby spuriously inflating the apparent accuracy of the CBC model. Consequently, we interpreted fPLI and AUS in parallel: a cat was considered FP-positive if at least one test was positive [25].

Previous estimates of diagnostic performance at the cut-offs used here include, for fPLI: Se 61% (95% CI 36–82%) and Sp 55% (95% CI 39–70%) in 60 cats [13]; Se 65% (95% CI 43–83%) and Sp 63% (95% CI 26–90%) in 31 cats [12]; and Se 74% (mild FP) to 82% (marked FP) with Sp 74% in another cohort [14]. For AUS, Se 84% (95% CI 60–97%) and Sp 75% (95% CI 48–93%) were reported in 35 cats [16]. Using conservative point estimates of Se 65% / Sp 65% for fPLI and Se 85% / Sp 75% for AUS, parallel interpretation produces combined Se ≈ 95% and Sp ≈ 49%. At a pre-test probability of FP of 50%, a cat negative on both reference tests (classified in our study as "very low risk" of FP) had ≈ 95% probability of being truly FP-free. Conversely, a cat positive on at least one test had ≈ 65% probability of true FP, rising to ≈ 85% if both tests were positive. Because the CBC model is intended as a screening tool—where a negative result should be highly trustworthy while positive results will subsequently be confirmed by more specific testing—we prioritized reliable identification of FP-negative cats over FP-positive ones. Additionally, the relatively low Sp of the composite reference standard tends to underestimate the true Se of the index test [41]; thus, the actual Se of our CBC model may exceed the reported values.

A major limitation of the study relates to the precision of the differential leukocyte counts used for model construction. Although total WBC counts were obtained with high-quality automated analyzers offering excellent repeatability, manual differential counts were performed on only 100 leukocytes. This approach is susceptible to observer error and substantial sampling variation; for example, a true band neutrophil percentage (BN%) of 1% yields a 95% CI of 0.2–5.4% when based on 100 cells [42], a range considerably wider than the diagnostic cut-offs identified in our analysis. Counting 200 or 300 cells would narrow the 95% CI to 0.1–2.8% or 0.1–1.9%, respectively, albeit at the cost of longer processing time. Nevertheless, manual smear evaluation remains the only practical way to quantify band neutrophils, and our findings underscore the clinical value of reporting BN% and absolute band counts—particularly as in-house automated analyzers that omit this parameter are becoming widespread. Another notable shortcoming is the absence of data on neutrophil toxic changes, which were not routinely assessed by the analyzing laboratory. Toxic morphological changes reflect accelerated neutrophil turnover and immature release during acute inflammation [26, 31] and might have enhanced model performance; their inclusion merits future study.

Conclusions

The integration of routine CBC parameters provides a rapid, readily available screening tool with reasonable accuracy for identifying cats presenting with lethargy and anorexia that are at elevated risk of feline pancreatitis.

Methods

This retrospective cross-sectional investigation included 73 cats examined at three veterinary facilities in Central Poland between 2014 and 2020. All animals were evaluated for feline pancreatitis (FP) using a commercial feline pancreatic lipase immunoreactivity (fPLI) test and abdominal ultrasonography (AUS). Inclusion required owner confirmation that the cat: 1) showed lethargy with decreased appetite or complete anorexia for ≥ 2 days; 2) had no known chronic illnesses; 3) had never been diagnosed with FP previously; 4) had not received glucocorticoids in the preceding month. Each cat underwent examination by a board-certified small animal internal medicine specialist. Blood was drawn for standard hematology, biochemistry, and fPLI measurement. fPLI concentration (μg/L) was determined by monoclonal antibody-based ELISA (Spec fPL™) at IDEXX Laboratories GmbH (Ludwigsburg, Germany), with values ≤ 3.5 μg/L interpreted as normal and > 3.5 μg/L as elevated per manufacturer guidelines. Abdominal ultrasonography was conducted by an experienced veterinary radiologist using high-end equipment (MyLab 25 Gold, Esaote, Italy; HM70A, Samsung Electronics Ltd., UK). An ultrasonographic diagnosis of FP was made if ≥ 1 of the following was present: pancreatic width > 10 mm, irregular pancreatic contours, hypoechoic pancreatic parenchyma, hyperechoic peripancreatic mesentery/fat, or peripancreatic effusion. Hyperechoic parenchyma suggestive of fibrosis was also accepted as diagnostic [5, 10, 16]. Additional diagnostics (thoracic radiographs, echocardiography, etc.) were performed when clinically indicated.

Results from fPLI and AUS were interpreted in parallel [25]: cats were classified as very low risk of FP only if both tests were negative (fPLI ≤ 3.5 µg/L and normal pancreatic appearance on AUS); any positive result in either test indicated increased FP risk.

Hematology and biochemistry were performed at a reference veterinary laboratory. Complete blood count (CBC) was carried out using Abacus Vet5 (Diatron MI Zrt., Hungary) or Mythic 18 Vet (PZ Cormay S.A., Poland), and chemistry parameters with a BS-800 photometric analyzer (Mindray Medical Poland). Manual differential counts were performed on May-Grünwald-Giemsa-stained blood smears (Adamed Pharma S.A., Poland) under oil immersion (100×) using a Primo Star microscope (Zeiss, Germany). A total of 100 nucleated leukocytes were classified into band neutrophils, segmented neutrophils, eosinophils, basophils, monocytes, and lymphocytes by trained personnel. Basophils were excluded from subsequent analyses due to their rarity and questionable identification accuracy.

Concurrent conditions were defined as follows: anemia (Ht < 27%); hemoconcentration (Ht > 45% and TP > 80 g/L, or urea > 12 mmol/L with creatinine < 250 µmol/L); suspected acute kidney injury (creatinine > 250 µmol/L and urea > 12 mmol/L); suspected hepatopathy (ALT > 200 U/L without hyperthyroidism or TB > 17 µmol/L without anemia) [43]. Diabetes mellitus was confirmed by historical polyuria/polydipsia plus fructosamine > 400 µmol/L; hyperthyroidism by total T4 > 65 nmol/L; neoplasia by imaging and ultrasound-guided cytology/histology. Fever was recorded when rectal temperature exceeded 39.5 °C. Abdominal pain was assessed subjectively by the attending clinician.

Seven CBC variables were selected for analysis: total WBC, absolute neutrophil count, band neutrophil count (BNC), eosinophil count (EC), monocyte count (MC), lymphocyte count (LC), and neutrophil-to-lymphocyte ratio (NLR).

Ethical approval was not required under Polish law (Act of 15 January 2015 on the Protection of Animals Used for Scientific or Educational Purposes) because only clinically justified routine procedures were performed and the study was retrospective and analytical. Written owner consent was nevertheless obtained for every cat.

Continuous variables are reported as median, interquartile range (IQR), and range; group comparisons used the Mann-Whitney U test. Categorical data are shown as counts (n) and percentages. Each CBC parameter was first converted to a binary variable using the cut-off that maximized Youden's index (J) [24]. Association between dichotomized CBC variables and FP risk was tested with the G-test of maximum likelihood or Fisher's exact test (when any expected cell count was < 5), and quantified as crude odds ratios (ORcrude).

CBC parameters significantly associated with FP risk at $\alpha = 0.05$ in univariable screening were entered into multivariable logistic regression analysis [44] according to the model:

$$f(P,=,1) = \frac{1}{1 + e^{-(B_0,+,B_n,\times,X_n)}} \quad (1)$$

where e represents Euler's number (≈2.718), B0 denotes the intercept, and Bn are the regression coefficients corresponding to the selected CBC variables (Xn) that were retained after backward stepwise elimination. The strength of the association between each retained CBC parameter and FP risk was reported as the adjusted odds ratio (ORadj). Model fit was assessed with the Hosmer-Lemeshow goodness-of-fit test (H&L χ^2) and Nagelkerke's pseudo-R^2. The ability of individual CBC parameters and the final logistic regression-based CBC model to discriminate between cats at very low versus increased risk of FP was quantified by the area under the receiver operating characteristic curve (AUROC). AUROC values were classified as: ≥ 90% excellent, 80–89% good, 70–79% fair, and < 70% poor [24]. Differences in AUROC were tested using the nonparametric DeLong method [45]. For the optimal cut-off of the CBC model, diagnostic sensitivity (Se), specificity (Sp), positive likelihood ratio (LR+), and negative likelihood ratio (LR–) were determined. Ninety-five percent confidence intervals (95% CI) for proportions and likelihood ratios were computed using the Wilson score method and the log method, respectively [46]. The significance threshold (α) was 0.05, and all tests were two-tailed. Analyses were conducted using TIBCO Statistica 13.3 (TIBCO Software Inc., Palo Alto, CA, USA) and IBM SPSS Statistics 26 (IBM Corporation, Armonk, NY, USA).

All procedures were performed in full compliance with applicable guidelines and regulations.

Abbreviations

α=Significance level
AUROC=Area under ROC curve

AUS=Abdominal ultrasonography
BNC=Band neutrophil count
CBC=Complete blood count
CI 95%=95% confidence interval
DGGR=1,2-o-Dilauryl-Rac-Glycero-3-Glutaric Acid-(6′-Methylresorufin) Ester
FP=Feline pancreatitis
fPLI=Feline pancreatic lipase immunoreactivity
H&L χ^2 =Hosmer & Lemeshow chi-square test
IQR=Interquartile range
LR+=Positive likelihood ratio (likelihood ratio of a positive result)
LR-=Negative likelihood ratio (likelihood ratio of a negative result)
NLR=Neutrophil-to-lymphocyte ratio
NPV=Negative predictive value
PPV=Positive predictive value
ROC=Receiver operating characteristic
Se=Diagnostic sensitivity
Sp=Diagnostic specificity
WBC=Total leukocyte count (white blood cell count)

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Conflict of Interest: None

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Ethics Statement: No ethics commission approval for this study was required according to Polish legal regulations (the Act on the Protection of Animals Used for Scientific or Educational Purposes of 15 January 2015) as only routine diagnostic procedures essential given the clinical status of the cat were performed and the study was purely analytical. An informed consent of each cat's owner for participation in the study was obtained.

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