Research Article

An Investigation of Certain Inflammatory Markers in Whole Blood in Patients with Feline Panleukopenia

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Abstract

Feline Panleukopenia Virus (FPV) is a highly contagious viral infection, most commonly observed in young and unvaccinated cats, characterized by high morbidity and mortality rates. Although several diagnostic methods exist, recent studies have increasingly emphasized the use of inflammation indicators derived from complete blood count (CBC) in the diagnosis and management of FPV. In the present study, CBC results from 25 infected cats (older than 45 days, regardless of sex) presenting to a veterinary hospital with complaints of vomiting and diarrhea, along with 10 healthy cats, were evaluated. Derived hematological indices including Neutrophil-to-Lymphocyte Ratio (NLR), Lymphocyte-to-Monocyte Ratio (LMR), Platelet-to-Lymphocyte Ratio (PLR), Systemic Immune-Inflammation Index (SII), Systemic Inflammatory Response Index (SIRI), Pan-Immune Inflammation Value (PIV), and Neutrophil-Monocyte-Lymphocyte Ratio (NMLR) were analyzed. The study demonstrated statistically significant differences in NLR ($p = 0.008$), PLR ($p = 0.019$), NMLR ($p = 0.007$), SII ($p < 0.001$), SIRI ($p = 0.001$), and PIV ($p < 0.001$). These findings suggest that such parameters may serve as valuable tools in the diagnosis, clinical management, and prognostic assessment of FPV. It is concluded that with further comprehensive studies, the clinical utility of these indices will gain increasing importance.
Keywords: FPV, Inflammation Index, Whole Blood, NLR, SIRI

Introduction

Feline panleukopenia virus (FPV) is a non-enveloped, single-stranded DNA parvovirus that is widely distributed among domestic and wild felids worldwide (Neuerer et al., 2008; Sykes & Parrish, 2021). The virus can also infect certain carnivores, such as foxes and raccoons, as well as some primate species (Scott, 1987). FPV possesses a ~5 kb genome with terminal hairpin structures that are essential for viral replication and transcription (Cotmore & Tattersal, 2013), 2013). Clinically, infection is characterized by severe leukopenia and acute enteritis, particularly in kittens and unvaccinated cats (Pedersen, 1988; Decaro & Buonavoglia, 2012). Animal shelters and other high-density environments facilitate viral transmission and have been associated with significant morbidity and mortality during outbreaks (Addie et al., 1998).

Experimental studies have demonstrated that FPV can hemagglutinate erythrocytes from various species and infect a broad range of hosts under laboratory conditions; however, this does not necessarily indicate natural susceptibility (Decaro & Buonavoglia, 2012; Tuzio, 2021). FPV is closely related to canine parvovirus type 2 (CPV-2), which emerged in the 1970s and subsequently evolved into the CPV-2a, CPV-2b, and CPV-2c variants (Nakamura et al., 2001). The genetic and antigenic similarity between FPV and CPV-2 has facilitated cross-species adaptation, enabling certain CPV variants to infect cats (Decaro & Buonavoglia, 2012).

In addition to causing bone marrow suppression and gastrointestinal damage, FPV infection induces

significant hematological alterations that may aid in disease assessment. Recently, inflammatory biomarkers derived from complete blood counts, including the neutrophil-to-lymphocyte ratio (NLR), lymphocyte-to-monocyte ratio (LMR), and platelet-to-lymphocyte ratio (PLR), have gained attention as indicators of disease severity and prognosis (Rejec et al., 2017). These markers are associated with characteristic hematological abnormalities such as leukopenia and lymphopenia and offer a rapid, cost-effective approach for risk assessment and outbreak management, particularly in shelter populations (Desai et al., 2021; Yanar, 2024).

Materials and Methods

Study Cohort

The study population consisted of 25 cats with feline panleukopenia and 10 clinically healthy controls, all older than 45 days of age and of either sex, that were presented to the Animal Hospital of the Faculty of Veterinary Medicine, Kırıkkale University.

Clinical Examination Protocol

Cats admitted to the Internal Medicine Clinic of the Animal Hospital, Faculty of Veterinary Medicine, Kırıkkale University, with a history of vomiting and diarrhea were enrolled in the study. Information regarding age, breed, sex, and vaccination status was recorded, and a complete physical examination was performed. Vital parameters were documented, and cats were subsequently evaluated as suspected feline panleukopenia cases. Definitive diagnosis was established using additional diagnostic methods to determine the underlying etiology.

The control group comprised clinically healthy cats presented for routine vaccination and health screening. Complete blood count, serum biochemical parameters, and physical examination findings were obtained and recorded for all control animals.

Infected Group

A total of 25 cats with feline panleukopenia were included in the study. The infected group was composed of cats exhibiting clinical signs compatible with feline panleukopenia, including vomiting, diarrhea, depression, and anorexia. Following clinical assessment, blood samples were collected and subjected to complete blood count analysis. Cats demonstrating leukopenia, as evidenced by total leukocyte (WBC) counts below the reference range, were further evaluated using a lateral flow immunochromatographic rapid antigen test for feline panleukopenia virus (FPV). Cats testing positive were considered infected and subsequently included in the study group.

Control Group

Ten clinically healthy cats presented for routine vaccination and general health assessment were enrolled as the control group. Inclusion criteria for the control group consisted of the absence of clinical signs of disease and hematological and biochemical parameters within reference ranges, as determined through routine health screening examinations performed at the Animal Hospital of Kırıkkale University Faculty of Veterinary Medicine.

Collecting Samples and Laboratory Analyses

For hematological assessment, 2 mL of blood was collected from the cephalic vein (vena cephalica antebrachii) of each cat into EDTA-containing tubes. Samples were analyzed within 30 minutes of collection using an automated hematology analyzer (Mindray BC-5000, China) to obtain complete blood count (CBC) parameters. The resulting hematological data were recorded for subsequent statistical analysis.

Application of Rapid Tests

Rapid diagnostic test kits are widely recognized as a valid diagnostic tool for the detection of feline panleukopenia virus (FPV) infection. As FPV is shed through the gastrointestinal tract and is associated with prominent enteric manifestations, fecal or rectal swab samples were collected from all cats in both the infected and control groups for the detection of FPV antigen. For fecal samples, the collection swab provided with the test kit was used to obtain the required amount of fecal material. In cases where rectal swab samples were collected, the procedure was initiated directly using the swab specimen. The fecal sample or rectal swab was thoroughly mixed with the dilution buffer supplied in the test kit to ensure adequate sample homogenization. The resulting suspension was allowed to stand on a flat surface for sedimentation of coarse particulate matter. Subsequently, 10 µL (approximately three drops) of the clarified diluted sample was transferred using the provided dropper and dispensed into the sample well of the test cassette positioned on a level surface. Test results were interpreted after an incubation period of 8 minutes according to the manufacturer's instructions (VetExpert FPV Ag Test, Poland). The presence of a control line was required to validate the test. Samples yielding invalid results, indicated by the absence of a control line, were excluded from the study.

The appearance of a test line was interpreted as a positive result for FPV antigen detection, regardless of the intensity or clarity of the line. Test interpretation and result classification were performed strictly in accordance with the manufacturer's guidelines, with the presence of the test line serving as the sole criterion for a positive result.

Calculating the Inflammation Indıcators

In the present study, seven inflammatory biomarkers were evaluated. The calculated inflammatory indices were derived from the complete blood count (CBC) data obtained from each animal. Hematological inflammatory indices were calculated using formulas previously described in the literature. The evaluated parameters and the corresponding formulas used for their calculation are presented below;

- Notrophile Lymphosit Ratio (NLR) = Notrophile Count/Lymphosite Count

- Lymphosite Monocyte Ratio (LMR) = Lymphosite Count/ Monocyte Count
- Platelete Lymphosite Ratio (PLR) = Platelete Count/Lymphiste Count
- Systemic Inflamatoric Immune Index (SII) = Trombocyte Count X Notrophile Count/Lymposite Count
- Systemic Inflamatoric Response Index (SIRI) = Notrophile Count X Monocyte Count/Lymphosite Count
- Pan Immune Inflamatoric Value (PIV) = Nortophile Count X Monocyte Count X Trombocyte Count/Lymphosite Count
- Notrophile Monocyte Lymphosite Raito = Monocyte Count + Notrophile Count / Lymphosite Count

Statistical Analyses

The Shapiro-Wilk test was used to assess the normality of the data distribution across groups. Mean and standard deviation values were reported for normally distributed data, while median and interquartile range (IQR) values were reported for non-normally distributed data. The Student's t-test was used to compare data with a normal distribution, while the Mann-Whitney U test was applied to data with a non-normal distribution. A p-value of <0.05 was considered a statistically significant difference. The Jamovi Project 2.6 (Australia) was used to perform the statistical analyses.

Results

The study evaluated complete blood count results obtained from the control and infected groups. The leukogram findings and statistical analyses of the complete blood count are presented in Table 1. When the leukogram findings across the study groups were evaluated, it was observed that the total white blood cell (WBC) counts of cats infected with panleukopenia were below the reference ranges. Leukopenia was detected in all infected animals. It was determined that there was a statistically significant difference between the WBC counts of the control group and the infected group ($p<0.05$). Similarly, it was observed that the counts of neutrophils (NEU), lymphocytes (LEU), monocytes (MON), eosinophils (EOS), and basophils (BAS) were lower than those in the control group and showed statistically significant differences ($p<0.001$, $p<0.05$).

Table 1. Results of Haemogram

	CONTROL		INFECTED		
	Mean (Min-Max)	Median (IQR)	Mean (Min-Max)	Median (IQR)	P Değeri
WBC	10.6 (5.50-16.3)	9.52 (4.80)	1.82 (0.26-4.78)	1.24 (2.16)	**<0.001**
NEU	7.19 (3.51-12.54)	7.21 (2.33)	0.92 (0.05-3.35)	0.71 (0.84)	**<0.001**
LYM	2.78 (0.92-6.05)	2.34 (1.41)	0.67 (0.11-2.24)	0.29 (0.83)	**<0.001**
MON	0.17 (0.08-0.40)	0.13 (0.08)	0.09 (0.00-0.94)	0.05 (0.06)	**<0.001**
EOS	0.39 (0.21-0.76)	0.32 (0.14)	0.12 (0.00-0.55)	0.03 (0.22)	**<0.001**
BAS	0.02 (0.00-0.10)	0.01 (0.02)	0.00 (0.00-0.06)	0.00 (0.00)	**0.002**

The study evaluated the results of complete blood count parameters for the control and infected groups in light of parameters reported in the literature. The first parameter examined was the neutrophil-to-lymphocyte ratio (NLR). It was found that the mean value in the infected group was lower than that in the control group, and a similar result was observed for the median value. In the intergroup statistical analysis, a significant statistical difference was observed between the control group and the infected group (P=0.008). A similar situation was observed for the platelet-to-lymphocyte ratio. The mean and median values for the infected group were lower, and a statistically significant difference between the groups was detected (P=0.019). The situation was different for the lymphocyte-to-monocyte ratio. The mean for the infected group was found to be higher than that of the control group, and no statistically significant difference was found between the groups (P=0.315). For SII and SIRI values, the mean values in the infected group were found to be higher than those in the control group. A statistically significant difference was detected between the groups for SII and SIRI values ($p<0.001$, P=0.001). For the remaining PIV and NMLR values, excluding the 5 parameters, the differences between the groups were found to be statistically significant ($P<0.001$, P=0.007), and the mean values of the infected group were lower than those of the control group. The mean, median, and statistical results for the hematological index parameters are shown in Table 2

Table 2. Results of Haematological Index

	CONTROL		INFECTED		
	Mean (Min-Max)	Median (IQR)	Mean (Min-Max)	Median (IQR)	P Value
NLR	3.02 (1.32-4.77)	2.77 (1.95)	2.46 (0.23-19.7)	1.29 (1.14)	**0.008**
LMR	17.2 (7.62-28.8)	13.9 (10.2)	17.9 (0.00-112)	9.67 (20.7)	0.315
PLR	125 (40.0-295)	93.2 (108)	333 (64.7-1135)	192 (131)	**0.019**
SII	751 (427-1261)	625 (461)	183 (14.0-636)	134 (156)	**<0.001**

SIRI	0.53 (0.19-1.62)	0.41 (0.26)	0.39 (0.00-6.80)	0.04 (0.17)	**0.001**
PIV	122 (57.0-261)	106 (92.7)	23.7 (0.00-340)	6.88 (8.23)	**<0.001**
NMLR	3.20 (1.53-5.11)	3.01 (1.97)	2.56 (0.24-19.7)	1.35 (1.37)	**0.007**

Discussion

This study evaluated seven hematological inflammatory indices derived from complete blood count parameters in cats with feline panleukopenia virus (FPV) infection. Consistent with previous reports, FPV-infected cats exhibited marked leukopenia, with all infected animals demonstrating WBC counts below the reference range (Tuzio, 2021). Significant reductions in neutrophil, lymphocyte, monocyte, eosinophil, and basophil counts were also observed, reflecting the well-established tropism of FPV for rapidly dividing cells within the bone marrow and lymphoid tissues (Truyen et al., 2009; J. E. Sykes & Parrish, 2021). These findings further support leukopenia as a hallmark hematological feature of FPV infection.

Although anemia has frequently been reported in FPV-infected cats (Kadam et al., 2022; Modi et al., 2024), no significant differences in RBC, HGB, or HCT values were detected between groups. Nevertheless, infected cats exhibited numerically lower mean erythrocyte-related values than healthy controls. Previous studies suggest that anemia in FPV may depend on disease stage, severity of bone marrow suppression, hydration status, and concurrent complications (Truyen et al., 2009; Gülersoy et al., 2023). Similarly, erythrocyte indices (MCV, MCH, and MCHC) did not differ significantly between groups, in agreement with most published reports describing FPV-associated anemia as predominantly normocytic and normochromic (Kadam et al., 2022; Gülersoy et al., 2023; Modi et al., 2024).

Among the inflammatory indices evaluated, NLR was significantly lower in FPV-infected cats. This finding is consistent with previous studies and likely reflects the profound neutropenia caused by FPV-induced bone marrow suppression (Yanar, 2024; Aydin, 2025). In contrast to many inflammatory disorders where NLR increases, the severe cytopenic nature of FPV leads to a marked reduction in circulating neutrophils, making low NLR a potentially useful indicator of disease severity and prognosis.

LMR did not differ significantly between groups, despite a higher mean value in infected cats. Similar findings have been reported previously (Aydin, 2025). The absence of a significant difference may be explained by the simultaneous depletion of both lymphocytes and monocytes in FPV infection, resulting in relative preservation of their ratio (Tuna & Kirkulak, 2023). However, the limited number of studies investigating LMR in feline panleukopenia warrants further research.

PLR was significantly elevated in infected cats, supporting previous observations in FPV cases (Donato et al., 2023; Yanar, 2024; Aydin, 2025). This increase appears to be primarily driven by severe lymphopenia rather than thrombocytosis. Given its accessibility and low cost, PLR may serve as a useful adjunctive biomarker for assessing inflammatory burden and prognosis in cats with FPV.

Both SII and SIRI were significantly lower in infected cats. While these indices are often elevated in inflammatory diseases, FPV represents a unique condition characterized by profound immunosuppression and pancytopenia (Xia et al., 2023; Aydin, 2025). Consequently, reductions in neutrophil and platelet counts appear to outweigh inflammatory responses, resulting in lower SII and SIRI values. These findings suggest that both indices may provide useful information regarding the degree of immune suppression associated with FPV infection.

To our knowledge, this is among the first studies evaluating PIV in cats with FPV. PIV values were significantly lower in infected animals, likely reflecting the combined effects of neutropenia, monocytopenia, lymphopenia, and altered platelet dynamics. Although extensively investigated in human medicine as a prognostic inflammatory biomarker (Guven et al., 2022; Kuang et al., 2024), its role in feline infectious diseases remains largely unexplored. The present results indicate that PIV may have potential clinical utility in FPV and deserves further investigation.

Similarly, NMLR was significantly reduced in the infected group. Given the severe alterations in neutrophil, monocyte, and lymphocyte populations associated with FPV infection, this index appears capable of reflecting disease-associated systemic immune dysregulation. Although evidence regarding NMLR in veterinary medicine remains limited, the significant findings obtained in this

study suggest that it may represent a practical and cost-effective prognostic biomarker for cats with FPV.

Overall, the present findings indicate that NLR, PLR, SII, SIRI, PIV, and NMLR are significantly altered in cats with feline panleukopenia and may provide valuable adjunctive information for disease assessment and prognostic evaluation. Among these indices, NLR, SII, SIRI, PIV, and NMLR appear particularly promising because they reflect the characteristic cytopenic and immunosuppressive pathophysiology of FPV infection. Further studies involving larger populations and outcome-based analyses are required to establish their prognostic value in clinical practice.

Ethical Approval

This study was approved ethical status by the Kırıkkale University Local Ethics Committee on Animal Experiments (Decision Number: 2025/01/07)

Conflict of Interest

The outhors declared that there is no conflict of interest.

Authors' Contributions

This research was designed by BYG and YP. In Data collection adn processing part was made by BYG and YP. Analysis were made by YP. Literature review protocols were realised by BYG and YP. The article was written by BYG and YP.

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