Feline panleukopenia: A SURVEY ON PATHOLOGY, RISK FACTORS AND HEMATOLOGICAL CHANGES IN INFECTED CATS

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ABSTRACT

This study was conducted at Amy Veterinary Clinic from March 1 to July 31, 2023. A survey was carried out on 141 cats brought to the clinic for treatment based on the clinical and subclinical symptoms. This study aimed to learn about the changes in hematological parameters after cats were identified as infected with *Feline panleukopenia virus* (FPV) by FPV Ag test kit. The results showed that 65.24% of cats were suspected of being infected with FPV virus among the total surveyed cats, and 84.78% of cats were positive for FPV via rapid test kit in the total number of suspected cases. The rate of FPV infection was not affected by sex, age, normanagement method. Cats aged from 2 to 12 months old had the highest disease rate (95.31%) and over 12 months of age accounted for the lowest rate (45.45%). The prevalence of FPV was higher in unvaccinated cats (89.87%) compared to those vaccinated (53.84%). Blood physiological tests showed that on the first day of FPV infection, the average white blood cell count decreased to 4,582 x 10^9/L, mean platelet count decreased to 70.01 x 10^9/L. The difference in these parameters on day 1 compared with the reference range was highly significant ($P < 0.001$). After 3 days and 5 days of treatment, the mean white blood cell count and mean platelet count increased markedly; the remaining parameters (monocytes, granulocytes) also increased but not significantly. The logistic regression equation states that if hematological parameters rose by one unit of measurement following three days of FPV therapy, the likelihood of cat survival (OR) increased correspondingly.

Keywords: *Cat, clinical diagnosis, Feline panleukopenia Virus, hematological, treatment.*

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1. INTRODUCTION

Feline panleukopenia is a very contagious disease that frequently results in death in cats [1, 2]. *Feline panleukopenia virus* (FPV) is a non-enveloped, icosahedral, single-stranded DNA virus [3] that belongs to the genus Protoparvovirus [4]. It may survive in the environment for months or years and is extremely resistant to both chemical and physical influences [5]. For this reason, the virus can spread indirectly through contaminated people or improperly disinfected objects in addition to direct contact. Workers and equipment in shelters have the potential to act as carriers, putting exposed cats in danger [6]. Furthermore, canine *parvovirus* (CPV) [7] and infectious FPV [8] can be shed by healthy immunocompetent cats that have an asymptomatic infection, making them a significant source of contamination of the environment [8].

Because FPV's DNA is single-stranded, it needs cellular DNA polymerase to replicate, which causes the virus to divide quickly in cells during the S - phase of division [6, 9]. Particularly impacted are intestinal epithelial cells, lymphatic

tissue, and bone marrow [10, 11]. Fever, vomiting, diarrhea, anorexia, and/or dehydration are the most typical clinical symptoms [9, 11]. The disease's progress is frequently peracute, which results in death, especially in kittens [1, 12]. The aim of the present study was to describe disease prevalence, risk factors, physiology changes, and treatment effectiveness in cats infected with *Feline panleukopenia virus* (FPV).

2. MATERIALS AND METHODS

2.1. Study sites and methods

This research was conducted at Amy Veterinary Clinic in Thu Duc city in the period of six months from March to July 2023. Unhealthy cats admitted to the clinic were clinically examined and recorded involved information including age, sex, breed, body, and health condition. For cats with digestive symptoms consisting of vomiting and diarrhea, samples of blood and fecal swabs were continuously collected. The fecal swabs were collected from the cat's anus and tested for FPV using rapid antigens kit test (Careside, Korea) following the manufacturer's instruction to determine whether the cat was infected with enteric viruses. The blood samples collected from infected cats with the digestive symptoms were tested for hematological changes.

2.2. FPV examination by rapid test kit

For testing the infection of FPV, after collecting fecal swabs, the samples were dipped into the tube containing the diluent, then stirred for 10 seconds. The next step was adding 4 – 5 drops of diluent to the S zone of the test kit, waiting then reading the results after 5 – 10 minutes. The cat was positive for FPV when the test kit appeared on both S and T lines. On the contrary, the cat was negative for the *panleukopenia virus*.

2.3. Survey of hematological parameters

The number of red blood cells, white blood cells (Lymphocyte, monocyte, granulocytes, eosinophils), platelets and hemoglobin content were detemined according to Gülersoy *et al.* (2023) [13].

Blood sampling process to check physiology changes: First, blood is taken in the morning when the cat had not eaten or exercised. The blood samples were preserved with an anticoagulant such as EDTA or sodium citrate. After sampling, blood physiological parameters were analyzed using a physiological index analyzer (BC - 2800Vet - MINDRAY).

Determination of the hematocrit index (Ht): A Wintrobe tube, a glass tube 10 cm long and 3 mm in diameter, graduated in centimeters was used. Blood was aspirated with a syringe with a long needle and put into the Wintrobe tube to the zero mark. The Wintrobe tube was centrifuged at 3000 rpm for 30 minutes. After centrifugation, the red blood cells that settled formed a column. The height of this red blood cell column was meased by reading the value on the scale of the Wintrobe tube. The hematocrit value (Ht) was calculated by taking the average between the highest and lowest levels of the sedimented red blood cell column [14].

2.4. Treatment method

This study used a treatment regimen to enhance the body's resistance to the disease, treat symptoms, and prevent secondary infections such as marbofloxacin (5 mg/kg body weight, SC, once a day), 0.9% NaCl or 5% glucose infusion, vitamin C, vitamin B12 (0.25 - 1.0 mg/kg/day, PO), Fe (II) sulfate (10 - 20 mg/day, PO), amino acids, gastric acid neutralizer aluminum hydroxide, meloxicam (0.3 mg/kg body weight, SC, once a day), atropine sulfate (0.05 mg/kg body weight, SC, twice a day), vitamin K (2.5 - 5 mg/kg body weight, SC, once a day) for significant improvement in blood physiological indices after 5 days of treatment.

2.5. Statistical and data analysis

Data on the prevalent rates of disease based on vaccination status, age, sex, breed, and management were statistically processed and analyzed using the Chi-Square test in Minitab Pro software version 17.0 and Microsoft Excel 2010.

3. RESULTS AND DISCUSSION

3.1. Prevalence of cats with gastrointestinal symptoms

Table 1. Prevalence of FPV - infected cats and suspected cats

Parameter	No. of surveyed cats	No. of infected cats	Prevalence (%)
No. of suspected cats	141	92	65.24
No. of infected cats by rapid kit test	92	78	84.78

Table 1 shows that suspected cats being infected with the *Feline panleukopenia virus* as determined by clinical diagnosis with gastrointestinal diseases accounted for 65.24% of the total number of cats surveyed. The percentage of positive cases as determined by rapid test kit accounted for 84.78%. The disease rate was quite high. According to a recent study in Hanoi and neighboring areas by Ngoc *et al.* (2021) [15], out of 216 cats surveyed, 83 cases showed clinical symptoms and were suspected of being infected with FPV, accounting for 38.43%. Through PCR analysis, 29 cases were identified as positive for FPV, accounting for 13.42% of total 216 surveyed cases and 34.94% of the total number of suspected cases (83 cases). Our result was higher than the finding in Bangladesh with a prevalence of 22.9% [16]. The cause of this difference may be due to differences in geographical location, number of surveyed cases, care methods as well as diagnostic methods.

3.2. FPV infection rates in cats by vaccination status, age group, sex, breed and management method

Table 2 shows that the FPV infection rate of unvaccinated cats was significantly ($P < 0.01$) higher than that of vaccinated cats (89.87% vs. 53.84%). This shows that vaccination of cats is very important to prevent *panleukopenia*. Rehme *et al.* (2022) [17] showed that the presence of *Feline panleukopenia* was significantly more likely in cats from unvaccinated cats than those vaccinated ($P < 0.001$).

Table 2. Prevalence of FPV infection in cats by vaccination, age group, sex, breed and mangement method

Factor	No. of surveyed cats	No. of FPV-infected cats	Prevalence (%)	P value
	n = 92	n = 78	84.78	
Vaccination status				
Vaccinated	13	7	53.84	0.003
Unvaccinated	79	71	89.87	
Age (month-old)				
< 2	17	12	70.58	0.000
2 – 12	64	61	95.31	
> 12	11	5	45.45	
Sex				
Male	41	35	85.36	0.889
Female	51	43	84.31	
Breed				
Native	52	44	84.61	0.959

Exotic	40	34	85.00	
Management				
Semi-scavenging	75	64	85.33	0.761
In-house raising	17	14	82.23	

Table 2 shows that the age group from 2 to 12 months was most susceptible to the disease, accounting for 95.31%. That is because at this age, cats are still growing, no longer have passive resistance from their mothers, and many owners have not vaccinated their cats after 45 days of age. The difference in age was highly significant ($P < 0.001$). According to Ngoc *et al.* (2021) [15], cats in the age group from 1 to 7 months old had the highest positive rate (48.39%), followed by the age group from 8 to 12 months (36.00%), and finally cats in the age group > 12 months old (18.52%). The diference was statistically significant ($P < 0.05$). Islam *et al.* (2010) [18] studing the prevalence of FPV infection in cats in Tangail, Bangladesh found that FPV infection was more common in cats under 2 months of age (29.62%) than in cats of 2 months to 1 year (21.43%), and > 1 year of age (11.76%). Rehme *et al.* (2022) [17] showed that the presence of *Feline panleukopenia* in young cats (4 weeks up to 2 years of age) was higher than in adult cats ($P = 0.008$).

The infection rate in male cats (85.36%) was higher ($P = 0.889$) than in female cats (84.31%). Native cats were similarly infected with FPV to exotic cats (84.61% vs. 85%) ($P = 0.959$). In-house raised cats showed lower disease rate semi-scavenging cats (82.23% vs. 85.33%, $P = 0.761$). However, all of the 3 factors did not show statistically significant effects on the disease ($P > 0.05$). This result was similar to that of Ngoc *et al.* (2021) [15] who indicated that FPV infection in male cats (36.96%) was higher than in female cats (32.43%) and exotic cats (37.50%) was higher than native cats (3.43%). Nevertheles, Islam *et al.* (2010) [18] showed that FPV infection was higher in female cats (26.92%) than in male cats (18.75%) although there was no statistically significant difference ($P > 0.05$).

3.3. Rate of clinical symptoms in cats infected with FPV

Table 3. Prevalence of clinical signs in FPV-infected cats

Clinical signs	No. of surveyed cats	No. of cats with signs	Prevalence (%)
Fatigue	78	78	100
Loss of appetite	78	73	93.58
Fever (≥ 39,5°C)	78	63	80.76
Foamy vomit	78	68	87.17
Bloody diarrhea	78	74	94.87

Table 3 shows that the clinical symptoms in cats infected with FPV appeared at different rates withthe main onesbeing lethargy, fatigue, loss of appetite, fever (≥ 39.5°C), and bloody diarrhea. These are typical symptoms of cats with FPV - induced *panleukopenia*. A few cats only showed lethargy, fatigue, and poor appetite, but not vomiting nor diarrhea. The survey results had many similarities with those of Sykes (2013) [11] showing that typical clinical manifestations account for different and quite high rates, in addition to atypical low symptoms such as drooling, pale mucous membranes, and eyes with a lot of discharge. According to studies by Greene (2012) [6], Inada *et al.* (1996) [19] and Prittie (2004) [20], the pressure of the virus, rapid replication in the small intestine and lymphoid tissues causes these characteristic symptoms. A study by Goddard and Leisewitz (2010) [21] shows that severe intestinal damage accompanied

by immunodeficiency causes severe diarrhea and vomiting due to intestinal villi atrophy and loss of large amounts of fluid, electrolytes and protein; consequently there may be a decrease in body weight loss, shock, and death may occur. This result was similar to that by Tu *et al.* (2023b) [22] in Can Tho city showing that common symptoms in cats infected with FPV ware lethargy, fatigue (100%), loss of appetite (93.02%), fever (88.24%), bloody diarrhea (76.74%), vomiting white foam, or yellow-green (65.12%). A study by Awad *et al.* (2018) [23] in Egypt also showed that cats infected with FPV showed signs of fatigue, fever, anorexia, vomiting, thirst, and diarrhea.

3.4. Changes in hematological indicators

On the first day of arrival at the clinic, among those positive for FPV, 50 random cases were chosen for blood physiological testing. The changes in hematological parameters of the cats being positive for FPV compared with the normal reference range are shown in table 4.

Table 4. Changes in hematological parameters of the cats being positive for FPV on the first day

Parameters	Physiological level	Result	Day 1			P value
			N	$\bar{X}$	SE	
White Blood Cell (10^9/L)	5.5 – 19.5	12.5	50	4.582	0.132	< 0.001
Lymphocyte (10^9/L)	0.8 – 7	3.9	50	2.248	0.229	< 0.001
Monocyte (10^9/L)	0 – 1.9	0.95	50	0.7324	0.0712	< 0.01
Granulocytes (10^9/L)	2.1 – 15	8.55	50	4.603	0.6	< 0.001
Eosinophils (%)	2 – 12	7	50	6.584	0.652	> 0.05
Red Blood Cells (10^{12}/L)	4.6 – 10	7.3	50	5.8387	0.198	< 0.001
Hemoglobin (g/dL)	93 – 153	123	50	99.82	3.05	< 0.001
Hematocrit (%)	28 – 49	38.5	50	30.35	1.1	< 0.001
Platelets (10^9/L)	100 – 514	307	50	70.01	3.53	< 0.001

The changes in most of the hematological parameters between the first day and the normal reference range were highly significant ($P < 0.001$), except for monocytes ($P < 0.01$) and eosinophils ($P > 0.05$). In addition, the most prominent is the average leukocyte count decreased to 4.582 x 10^9/L while the normal leukocyte count ranges from about 5.5 x 10^9/L to 19.5 x 10^9/L. And, the average platelet count decreased to 70.01 x 10^9/L compared to the normal platelet count of about 100 x 10^9/L - 514 x 10^9/L. According to a study of Kruse *et al.* (2010) [2], in cats infected with FPV, the average white blood cell count decreased to 1.8 × 10^3/µl, while the average white blood cell was 4.6 × 10^3/µl - 12.8 × 10^3/µl. Lymphocytes and granulocytes also decreased to 0.84 × 10^3/µl and 0.89 × 10^3/µl, respectively, while the average monocytes were still within the fluctuation range but at a low level of 0.1 × 10^3/µl. The number of mild red blood cells was 6.86 × 10^6/µl, while in normal cats, the number fluctuated from 7 × 10^6/µl - 10.7 × 10^6/µl. Other indicators such as normal hemoglobin, red blood cell density, average red blood cell volume, and average platelets did not change much and were still within the normal ranges. The hematological parameters in FPV-infected cats in our study were in agreement with findings in India

[24] and Turkey [13]. The study of Tu *et al* (2023a) [25] also showed a significant decrease in blood physiological values, especifically leukopenia, thrombocytopenia, and anemia.

3.5. Comparison of changes in some hematological parameters on day 1 and day 3 after of treatment

Table 5. Changes in hematological parameters on day 1 and day 3 of treatment

Parameters	Physiological level	N	Day 1		Day 3		P value
			$\bar{X}$	SE	$\bar{X}$	SE	
White Blood Cell (10^9/L)	5.5 – 19.5	50	4.582	0.132	9.533	0.864	< 0.001
Lymphocytes (10^9/L)	0.8 – 7	50	2.248	0.229	4.566	0.361	< 0.001
Monocytes (10^9/L)	0 – 1.9	50	0.7324	0.0712	0.8572	0.0953	< 0.05
Granulocytes (10^9/L)	2.1 – 15	50	4.603	0.6	4.95	0.663	< 0.05
Eosinophils (%)	2 – 12	50	6.584	0.652	6.621	0.622	> 0.05
Red Blood Cells (10^{12}/L)	4.6 – 10	50	5.387	0.198	5.795	0.242	0.001
Hemoglobin (g/dL)	93 – 153	50	99.82	3.05	100.74	3.35	> 0.05
Hematocrit (%)	28 – 49	50	30.35	1.1	31.05	1.2	< 0.05
Platelet (10^9/L)	100 - 514	50	70.01	3.53	94	6.83	< 0.001

The changes in white blood cells, lymphocytes, red blood cells, and platelets were highly significant ($P \leq 0.001$). The changes in monocytes, granulocytes and hematocrit were also statistically significant ($P < 0.05$). The remaining indicators (eosinophils and hemoglobin) were not statistically significant ($P > 0.05$). The average white blood cell count on day 3 (9.533 x 10^9/L) clearly increased compared to that recorded on day 1 (4.582 x 10^9/L). The average platelet counts on day 3 (94 x 10^9/L) also increased significantly compared to day 1 (70.01 x 10^9/L) (Table 5).

3.6. Comparison of changes in hematological parameters on day 1 and day 5 of treatment

Table 6. Changes in hematological parameters on day 1 and day 5 of treatment

Parameters	Physiological level	N	Day 1		Day 5		P value
			$\bar{X}$	SE	$\bar{X}$	SE	
White Blood Cell (10^9/L)	5.5 – 19.5	50	4.58	0.13	11.32	1.06	< 0.001
Lymphocytes (10^9/L)	0.8 – 7.0	50	2.248	0.229	4.818	0.437	< 0.001
Monocytes (10^9/L)	0 – 1.9	50	0.732	0.071	0.942	0.107	< 0.05
Granulocytes (10^9/L)	2.1 - 15	50	4.603	0.6	5.411	0.719	0.001
Eosinophils (%)	2 – 12	50	6.584	0.652	6.414	0.685	> 0.05
Red Blood Cells (10^{12}/L)	4.6 – 10	50	5.387	0.198	5.507	0.439	> 0.05
Hemoglobin	93 - 153	50	99.82	3.05	99.08	3.96	> 0.05

(g/dL)							
Hematocrit (%)	28 – 49	50	30.35	1.1	30.36	1.33	> 0.05
Platelet (10^9/L)	100 - 514	50	70.01	3.53	113.12	9.72	< 0.001

The changes in hematological parameters between the first and fifth day of treatment show that the changes in the number of white blood cells, lymphocytes, granulocytes, and platelets were highly significant ($P \leq 0.001$). The change in monocytes was also statistically significant ($P < 0.05$). The remaining indicators were not significantly changed ($P > 0.05$). The most obvious change was in the average white blood cell count, with the average value on day 5 (11.32 x 10^9/L) increasing more than double compared to day 1 (4.58 x 10^9/L). The average platelet counts on day 5 (113.12 x 10^9/L) increased nearly double compared to day 1 (70.01 x 10^9/L) (Table 6).

3.7. Comparison of changes in hematological parameters of cats on day 1, day 3 and day 5 of treatment

Table 7. Comparison of changes in hematological parameters in cats infected with FPV on day 1, day 3 and day 5 of treatment

Parameters	Physiological level	N	Day 1	Day 3	Day 5	P value
			$\bar{X}$	$\bar{X}$	$\bar{X}$	
White Blood Cell (10^9/L)	5.5 – 19.5	50	4.58^b	9.53^a	11.32^a	< 0.001
Lymphocytes (10^9/L)	0.8 – 7	50	2.248^b	4.566^a	4.818^a	< 0.001
Monocytes (10^9/L)	0 – 1.9	50	0.732	0.857	0.942	> 0.05
Granulocytes (10^9/L)	2.1 - 15	50	4.603	4.95	5.411	> 0.05
Eosinophils (%)	2 – 12	50	6.584	6.621	6.414	> 0.05
Red Blood Cells (10^{12}/L)	4.6 – 10	50	5.387	5.795	5.507	> 0.05
Hemoglobin (g/dL)	93 - 153	50	99.82	100.74	99.08	> 0.05
Hematocrit (%)	28 – 49	50	30.35	31.05	30.60	> 0.05
Platelet (10^9/L)	100 - 514	50	70.00^b	94^a	113.12^a	< 0.001

Note: $^{a, b}$ Different letters indicate statistically significant difference.

Table 7 shows that the increase in the average white blood cell count, lymphocytes, and platelet of day 1 was highly different compared to day 3 and day 5 ($P < 0.001$). The remaining indicators also increased after 3 or 5 days of treatment, but not significantly.

The bone marrow, lymphoid cells, and intestines are infected and killed by FPV, which results in cytopathic effects [26]. In addition, as the gastrointestinal barrier is often destroyed in panleukopenic cats, intestinal bacteria can invade the bloodstream, leading to sepsis. As a result, cats with FPV frequently have aberrant hematological findings including leukopenia, which is characterized by neutropenia and lymphopenia [27]. A study by Pandey (2022) [26] in the Central Referral Veterinary Hospital (CRVH) of Nepal showed that fluid therapy, antibiotics, metronidazole, supportive therapy, and good nursing care are common treatment practices.

3.8. The relationship between hematological parameters after 3 days of treatment related to survival rate

Table 8. Correlation between hematological parameters after 3 days of FPV treatment and survival of sick cats

Parameters	OR (odds ratio)	Confident level (95%)	Logistic equation
White Blood Cells (10^9/L)	3.1	(1.27 – 7.31)	Y' = -3.48 + 1.117 WBC day 3
Monocytes (10^9/L)	320.1	(6.64 – 15423.37)	Y' = -1.178 + 5.77 Mono day 3
Granulocytes (10^9/L)	8.6	(1.71 – 43.52)	Y' = -1.868 + 2.156 Gran day 3
Eosinophils (%)	3.4	(1.45 – 7.79)	Y' = -3.14 + 1.213 Eos day 3
Red Blood Cells (10^{12}/L)	3.6	(1.66 – 7.77)	Y' = -4.96 + 1.280 RBC day 3
Hemoglobin (g/dL)	1.1	(1.03 – 1.17)	Y' = -7.20 + 0.0937 HGB day 3
Hematocrit (%)	1.4	(1.11 – 1.66)	Y' = -7.05 + 0.309 HCT day 3

From table 8, it can be seen that after 3 days of FPV treatment, if the number of white blood cells in the blood increased by 1 unit 10^9/L, the number of monocytes in the blood increased by 1 unit 10^9/L, the number of granulocytes increased by 1 unit 10^9/L, the number of eosinophils increased by 1%, the number of red blood cells increased by 1 unit 10^{12}/L, the hemoglobin content increased by 1g/dL, and the hematocrit increased by 1%. The probability of the cat's survival (OR) increased by 3.1 times, 320.1 times, 8.6 times, 3.4 times, 3.6 times, 1.1 times, and 1.4 times, respectively. Table 8 also presents the relationship between the above hematological parameters and the cat's survival probability expressed through the corresponding logistic equation.

After a period of treatment, the cases of recovery were recorded depending on the resistance of each cat, within a treatment period of 3 to 5 days. Over the treatment period, 58/78 (74.36%) cats recovered from the disease. According to actual records at the clinic, the cured cases are those the owner brought to the clinic in time and followed the doctor's instructions. There are some reasons why cats die from FPV: The virus attacks the body, develops rapidly and affects other organs in the body, leading to respiratory failure, heart failure, bleeding from natural holes, the virus causes bloody diarrhea due to intestinal epithelium bleeding, leading to a large reduction in blood volume in the blood vessels, causing low blood pressure, hypothermia and severe dehydration. Secondary infections from intestinal bacteria and intestinal villi that do not regenerate after recovery make the body unable to absorb food [9 - 12, 19 - 21].

4. CONCLUSIONS

Up to 84.78% of suspected cats were positive for FPV. The rate of FPV infection was not affected by sex, breed, and management method. Age and vaccination significantly affected the rate of infection with this virus. The highest rate of infection was found in cats from 2 to 12 months old and the lowest in cats over 12 months old. Vaccinated cats had a lower rate of infection than those unvaccinated. Different clinical symptoms in cats infected with FPV appeared at different rates. The main symptoms were lethargy, fatigue, anorexia, poor appetite, and fever ($\geq$ 39.5°C), vomiting, and bloody diarrhea. These are typical symptoms of cats with FPV-induced *panleukopenia*. On the first day of FPV infection

the average white blood cell count and average platelet count decreased significantly, but increased after the treatment. However, after 3 days of treatment, if the hematological parameters increased by one unit of measurement, the probability of cat survival (OR) increased accordingly.

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