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Morphological and Biochemical Changes in Blood Parameters in Cats with Infectious Peritonitis

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Abstract. Feline infectious peritonitis is a feline disease, the causative agent of which is a mutant coronavirus, which leads to the death of young animals. Presently, this pathology is considered incurable, and therefore it requires a detailed study. The purpose of this study was to establish the features of clinical manifestation and haematological parameters in cats with infectious peritonitis. This paper presents the results of a clinical and laboratory study of 12 cats aged from 6 months to 3 years who were diagnosed with effusive and dry infectious peritonitis. Clinical, laboratory, and visual research methods were used. Laboratory analysis included a study of morphological and biochemical parameters of blood, cytological examination of effusion from the abdominal and pleural cavities, and a Rivalta test. As a result of cytological examination of effusion from these cavities, a high concentration of cells, macrophage accumulation, neutrophil phagocytosis, and red blood cells were detected in the entire field of view. It was found that the predictive value of the Rivalta test for feline infectious peritonitis is 62.5%. According to haematological examination, all sick animals were diagnosed with anaemia, lymphopenia, hypoalbuminemia, hyperglobulinemia, hyperbilirubinemia, increased activity of relative liver-specific enzymes (aspartate aminotransferase, alkaline phosphatase). Trobmocytopenia was observed in two animals, and an increase in blood markers of the functional state of the kidneys (creatinine, urea) was found in one cat. The serum albumin/globulin ratio should also be considered an important diagnostic indicator. Thus, with feline infectious peritonitis, this indicator should be < 0.4. In 11 sick cats, this ratio was characterized by values below 0.4, and in one animal this indicator was 0.46. In general, the obtained data of morphological and biochemical blood tests are not specific for feline infectious peritonitis, and therefore the authors of this paper recommend their comprehensive investigation for diagnostic purposes. An objective assessment of the available methods of laboratory diagnostics will contribute to the creation of a diagnostic protocol for feline infectious peritonitis

Keywords: coronavirus infection, clinical and haematological studies, Rivalta test, cytological examination

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Introduction

Coronaviruses cause respiratory and gastrointestinal diseases in most animal species. In cats, the coronavirus (FCoV) is represented by two biotypes, commonly referred to as feline intestinal coronavirus (FeCV) and feline infectious peritonitis virus (FiPV). It is believed that FeCV is associated with the development of a mild form of gastrointestinal infection, but cases of mild respiratory infections have also been established. It is known that the initial infection with the FCoV occurs by faecal-oral route. In some cats infected with FCoV, a mutation in the viral genome leads to a change in the tropism of the FCoV host cell from enterocytes to macrophages, which provokes a systemic infection known as feline infectious peritonitis (FIP) [1].

Feline infectious peritonitis is a disease with a high mortality rate that occurs in domestic and wild members of the feline family all over the world. The aetiological agent of the disease, feline coronavirus (FCoV), occurs in two different pathogenic types, which can be distinguished by their biological behaviour, but not by their morphology [2]. Presently, FIP stays a disease of cats with a 100% mortality rate and is understudied in veterinary practice [3].

This infectious pathology of cats is still one of the least researched viral diseases. Thus, for fifty years, it turns out to be a disease for which there is no diagnostic test, no vaccine for prevention, and no clear understanding of the mechanism of interaction of the virus with the body of a sensitive animal during the occurrence of the disease [4].

FIP can affect animals regardless of age but is most common in cats younger than 3 years and especially between 4 and 16 weeks of age. The disease is most often diagnosed in kennels (breeding cats), animal shelters, and places with a high concentration of animals per 1 m^2. Typically for an enzootic infection, the incidence of feline infectious peritonitis can vary widely over time. Mortality is very high, especially after the onset of clinical symptoms, although some cats can live with this disease for several weeks, months, or, in rare cases, years [11; 12].

Diagnosis of feline infectious peritonitis is quite complicated. This is explained by the fact that FIP does not have specific clinical symptoms. However, N. Pedersen [4; 5] states that the diagnosis of FIP is based primarily on consideration of the age of the animal, its origin, keeping conditions, the presence of other patients in contact, clinical symptoms, and physical examination data by a veterinary specialist. Cats aged 4-36 months who are surrounded by many other animals that show a persistent but undulating fever that does not respond to the use of distinct types of antibiotics should, first of all, be suspected of having FIP. More specific symptoms of FIP, which are noticed by owners or detected during a physical examination, will further narrow the range of diseases. Distension of the abdominal cavity due to the accumulation of exudate, dyspnoea in the presence of exudate in the pleural cavity, icterus of visible mucous membranes and skin, hyperbilirubinemia, visible masses on the kidneys and/or mesenteric lymph nodes, uveitis, and some other neurological symptoms associated with involvement of the brain or spinal cord in case of dry form of FIP. In 2019, N. Pedersen *et al*. [5] found that there is a group of preparations for FIP treatment.

The purpose of this study was to find the most characteristic changes in the morphological and biochemical indicators of blood and establish the features of the cytological pattern of exudate from the pleural and abdominal cavities in cats diagnosed with FIP.

Literature Review

S. Tasker [6] found that natural FCoV infections are transient in about 70% of cats, while persistent infection occurs in only 13% of animals. It is the latter that are permanent carriers of the virus. In most cases, coronavirus infection in cats is asymptomatic or manifests itself in minor disorders in the functioning of the gastrointestinal tract (for instance, diarrhoea, vomiting, and anorexia). Although occasionally, there is a severe course of the disease with damage to the gastrointestinal tract. It is also known that about 5-10% of cats are resistant to FCoV.

L. Golovko *et al*. [7] established the genetic component of GWAS and the predisposition of Burmese cats to FIP. F. Riemer [8] indicated epizootological features of feline infectious peritonitis. According to Riemer, FIP was more common in young males. Therewith, the status of castration was not associated with the development of the disease. Furthermore, no breed predisposition to FIP was found. Most of the cats belonged to the breed of domestic short-haired and mongrel cats.

N. C. Pedersen *et al*. [9] found that male cats, especially intact males, are not directly at risk of developing feline infectious peritonitis, as other authors claim [1].

Y. Yin *et al*. [10] report that most cats suspected for FIP belong to young animals and intact cats. The authors also found that the effusive form of infectious peritonitis is more common, namely in 85.8% of cats with suspected FIP.

Feline Infectious peritonitis has non-specific clinical symptoms. Thus, A. Kipar and M.L. Meli [11] state that anorexia, lethargy, weight loss, pyrexia, ophthalmic and neurological symptoms are non-specific for feline viral peritonitis.

According to recent studies, FIP has three main forms of course: effusive (wet), dry, and mixed. Therewith, A.M. Legendre *et al*. [12] established the median survival of cats for various forms of the disease. The effusive form of FIP is characterized by fluid accumulation in the abdominal and thoracic cavities – the median survival was 9 days in 21 cats with this form of the disease. The dry form of FIP is often characterized by pyogranulomatous infiltrates in the liver, kidneys, lymph nodes, eyes, and central nervous system. In the dry form, life expectancy is slightly higher and is within 1-200 days, which was found in 59 cats with FIP. In case of the mixed form, only 2 animals taking glucocorticosteroids were studied. Therewith, their life expectancy was 181 and 477 days, respectively.

The diagnosis of FIP is formed based on anamnesis data, results of physical examination, and general diagnostic procedures performed, as well as, if possible, data from post-mortem and microscopic examination of histopreparations. Therewith, classical indirect studies include morphological and biochemical blood tests with determination of the total content of whey protein, albumin and globulins, the value of the albumin/globulin ratio [12].

F. Mustaffa-Kamal *et al*. [13] noted the importance of T cells in the diagnosis of FIP. Thus, a decrease in the total number of white blood cells (WBC), lymphocytes, and T cells in the blood was observed during primary acute

infection for all experimental groups of animals with FIP. However, F. Riemer *et al*. [8] found that lymphopenia, which is much more common in the effusive form of FIP, was detected in only 26.8% of cats with a dry form.

E. Barker and S. Tasker [2] state that the clinical symptoms of feline infectious peritonitis can change over time, which often requires repeated clinical examinations. Non-specific clinical symptoms often increase and decrease, which is explained by the systemic inflammatory response, and are often found in cats with or without effusion. However, the absence of the above symptoms does not exclude feline infectious peritonitis. The authors also argue that routine clinical and laboratory studies in cats with FIP indicate the presence of a chronic systemic inflammatory response of the body, but these changes are not specific to the diagnosis of infectious peritonitis. That is why these studies are not considered informative. N. Safi *et al*. [14] conducted a haematological study of samples from nine cats with effusion and found that all animals had thrombocytopenia, hyperbilirubinemia, hyperglobulinaemia, and hypoalbuminemia. Three of these cats also had lymphopenia and jaundice.

J. Yousuf *et al*. [15] found that changes in indicators during biochemical blood tests in cats with FIP are variable and often non-specific, but there are several key abnormalities that doctors recommend considering before confirming the diagnosis. Thus, the above-mentioned authors indicate hyperglobulinaemia and hyperbilirubinemia. Hyperbilirubinemia occurs in 21-63% of cases of FIP and is more often observed in the effusive form, when the activity of the enzyme alanine aminotransferase (ALT), alkaline phosphatase (ALP) and γ-glutamyltranspeptidase is usually high (a moderate increase is also possible). In 89% of cases, hyperglobulinaemia is observed; often with hypoalbuminemia (detected in 64.5% of cases).

A more important diagnostic criterion for FIP is the determination of the ratio of albumin/globulin of blood or effusion. Thus, several variants of limit indicators were proposed that can potentially indicate the presence of feline infectious peritonitis. As a rule, this indicator is less than 0.4, which indicates a high probability of FIP [3].

Feline infectious peritonitis has always been considered the most common cause of death in young cats. Until 2019, it was also believed that feline infectious peritonitis is an incurable disease and ends in death [16].

Materials and Methods

The object of research was 12 cats with FIP aged from 6 months to 3 years, who were observed during 2021-2022. Among the cats under study, 8 had an effusive form of infectious peritonitis and 4 had a dry form. The study was performed based on the Department of Epizootology, Microbiology and Virology of the National University of Life and Environmental Sciences of Ukraine and the veterinary clinic "White Wolf" (Kyiv).

To establish a diagnosis, clinical and laboratory research methods were used, including morphological and biochemical blood tests. The haematological parameters were analysed in the veterinary clinic "White Wolf": for morphological studies, an automatic haematological analyser Mindray BC-5000 VET (China) was used, and an automatic analyser Goldsite GBA-1000 (China) was used to establish the parameters of biochemical parameters of blood serum. The data obtained were compared with a control group of clinically healthy cats (n = 12) who underwent a preventive examination in a veterinary clinic.

To establish a diagnosis of feline infectious peritonitis, cytological examination of exudate from the pleural and abdominal cavities and a Rivalta test were also performed.

For cytological examination, 2 ml of exudate was taken from the pleural and abdominal cavities into a test tube with an anticoagulant (test tubes with ethylenediaminetetraacetic acid were used). The use of anticoagulants prevents the formation of a clot, which complicates the reliable calculation of the cellular component of the exudate, as well as the possible inclusion of macrophages affected by feline coronavirus in the clot. Exudate from the thoracic and abdominal cavities in cats with an effusive form of infectious peritonitis was sampled under the control of an ultrasound machine (Mindray DP-10, China). T-FAST studies were performed using an ultrasound machine. In general, T-FAST studies in veterinary medicine are used to evaluate patients after acute blunt trauma or in the presence of pleural exudate. This study is performed in the left or right lateral position. Two examinations are conducted – transverse and longitudinal. The four fields of view are always evaluated, the condition of the lungs, heart, and the presence/absence of exudate are established.

After sampling the exudate to stabilize the biomaterial, the tube was turned over 6-7 times. Two smears were made on a slide. Each smear was left at room temperature to dry and then examined under a small and large magnification microscope (Optima Biofinder Bino 40x-1000x, Germany).

The Rivalta test is a rapid test for differential diagnosis of transudate from exudate. For its implementation, the Rivalta FIP-VETube diagnostic kit (Megacor, Great Britain) was used – a simple rapid test that allows quickly performing the necessary analysis. The essence of this method is that if there is a significant amount of protein in the exudate, a precipitate is formed when its drop is added to an aqueous solution of acetic acid. Before that, the test exudate was stained with methylene blue to evaluate the results of the study more accurately.

The obtained digital results were processed statistically, using Statistica 6.0 and Microsoft Excel 2019 software. Differences between the two indicators of the compared samples at $P < 0.05$, $P < 0.002$, and $P < 0.001$ were considered statistically significant.

Results and Discussion

In all cats under study, the first symptoms of feline infectious peritonitis were anorexia and lethargy. In 7 cats with an effusive form of FIP, an increase in abdominal volume was observed due to the accumulation of exudate. 1 cat had dyspnoea and compensatory tachycardia due to the accumulation of exudate in the thoracic cavity. Cats underwent ultrasound examination of the abdominal and thoracic cavities, which revealed the presence of a considerable amount of sonolucent exudate.

Among cats with a dry form of FIP, rapid weight loss was also observed. One cat had eye damage characterized by the development of keratitis and uveitis. According to research data from N.M. André *et al*. [1] a possible manifestation of feline infectious peritonitis may be the development

of rhinitis, but no such symptoms were found in 12 animals under study.

During abdominocentesis and pleurocentesis, straw-yellow, odourless, viscous fluid was aspirated (Fig. 1); in two cases, the liquid contained flakes of white fibrin.

Figure 1. Exudate from the abdominal cavity of a cat with feline infectious peritonitis. Viscous liquid, yellow in colour

The fluid from the pleural cavity also had a straw colour, a viscous consistency, without admixtures of fibrin (Fig. 2).

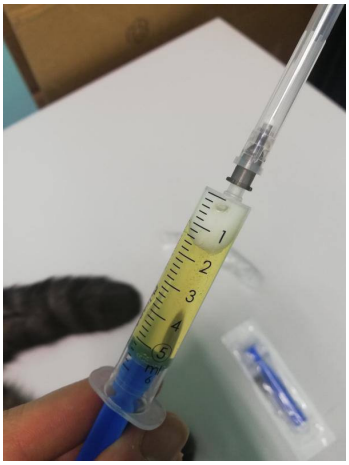

Figure 2. Exudate from the thoracic cavity of a cat with feline infectious peritonitis

During the Rivalta test in 5 out of 8 cats with an effusive form of FIP, the results were positive – sediment was formed during the study. That is, the predictive value of the Rivalta test for feline infectious peritonitis is 62.5%. According to S. Felten and K. Hartmann [3], the Rivalta test is affordable and fast to perform. Therefore, it can be recommended for the diagnostic protocol of examination of patients with exudate. According to these authors, this test shows sufficient sensitivity in the differential diagnosis of feline infectious peritonitis. If the test is negative, then other causes of exudate formation are much more likely than feline infectious peritonitis. However, the authors also claim that the predictive value of the Rivalta test for feline infectious peritonitis is only 66-81%.

To establish a diagnosis, cytological examination of exudate from the pleural and abdominal cavities was performed. Therewith, an elevated concentration of cells in the smears under study and the presence of red blood cells in the entire field of view were observed. Up to 60-70% of the cells found in the field of view were reactive macrophages of varying degrees of maturity (Fig. 3). Furthermore, activated macrophages with cytophagy were detected. Neutrophil phagocytosis and focal signs of emperipolesis were noted in two samples under study. In four samples, the presence of lymphocytes with many immunoblasts was observed, as well as small and medium-sized lymphocytes. Plasmocytes and neutrophils with a characteristic morphological structure were detected. In all 8 exudate samples under study, there was no pathological microflora.

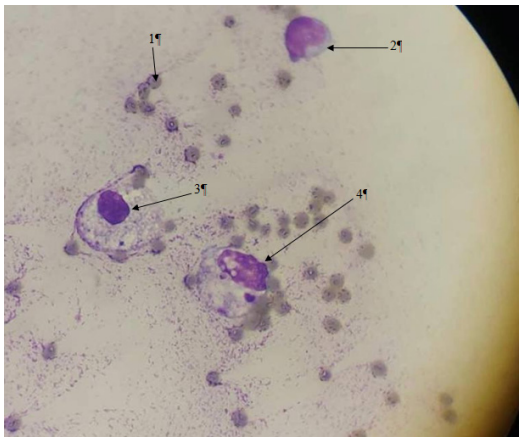

Figure 3. Microscopic picture of exudate from the abdominal cavity in a cat with diagnosed feline infectious peritonitis

Notes: 1 – red blood cells; 2 – T-lymphocyte; 3 – macrophage; 4 – macrophage with signs of phagocytosis.

In cats with a dry form of FIP, ultrasound diagnostics revealed inflammatory processes in the pleural and abdominal cavities, an increase in mesenteric lymph nodes. In two sick animals, a small amount of exudate was found between the intestinal loops.

To confirm the diagnosis, several laboratory tests were performed, including morphological and biochemical analysis of venous blood. Therewith, a range of indicators that are generally accepted in veterinary clinics and veterinary laboratories was determined [16].

During a morphological blood test, 12 cats were diagnosed with non-generative anaemia and lymphopenia, which is probably associated with the chronic course of the disease. Two animals were found to develop thrombocytopenia with a platelet count of 192 × 10^9/l at the reference rate of 200-600 × 10^9/l.

Notably, due to the development of anaemia in animals, a decrease in the haematocrit value was observed. In one cat, the number of red blood cells was 3.4 × 10^{12}/l, and the haematocrit value is 26% with reference values of 4.6-10 × 10^{12}/l and 36-55%, respectively. Therewith, the specified animal needed a blood transfusion.

Table 1 presents the results of a morphological blood test in 12 cats with feline infectious peritonitis and a similar number of cats in the control group.

Table 1. Morphological parameters of cat blood for feline infectious peritonitis (M ± m, n = 12)

Indicator	Unit of measurement	Experimental group of animals		Control group	Reference values
Red blood cells (RBC)	$x10^{12}$/l	4.27 ± 0.71*	↓	6.4 ± 0.32	4.6-10
Haemoglobin	g/l	97.7 ± 9.02	N	137.0 ± 10.12	93-153
ESR	mm/h	27.78 ± 11.13	N	11.0 ± 1.39	0-22
Haematocrit (HTC)	%	34.02 ± 3.74*	↓	50.0 ± 2.25	36-55
White blood cells (WBC)	$x10^9$/l	14.98 ± 1.38	N	13.2 ± 0.76	4.5-15.5
Juvenile neutrophils	$x10^9$/l	0	N	0	0
Band neutrophils	$x10^9$/l	0.21 ± 0.12	N	0.1±0.1	0-0.4
Segmented neutrophils	$x10^9$/l	10.76 ± 2.55	N	5.39 ± 3.19	2.5-12.5
Nuclear shift	juvenile+band/ segmented	0.02 ± 0.05	N	0.02 ± 0.01	0-0.08
Eosinophils (EO)	$x10^9$/l	0.6 ± 0.17	N	1.0 ± 0.02	0-1.6
Basophils (BA)	$x10^9$/l	0.04 ± 0.01	N	0	0-0.04
Lymphocytes (LYM)	$x10^9$/l	1.32 ± 0.62**	↓	6.0 ± 1.03	2.3-7.0
Monocytes (MON)	$*10^9$/l	0.69 ± 0.32	N	0.09 ± 0.25	0-1.9
Platelets (PLT)	$*10^9$/l	252.0 ± 67.56	N	497.0 ± 28.73	200-600

Note: * P < 0.05; * * P < 0.001, significant compared to the control group. ↓ – reduction of the indicator value; N – corresponds to the control limits

In general, morphological examination of the blood of patients with feline infectious peritonitis did not reveal specific changes that would be inherent in this particular disease. Based on the research results presented in Table 1, in the blood of cats with FIP, a 1.5-fold decrease in the number of red blood cells (P < 0.05) was observed, and the number of lymphocytes decreased 4.5-fold (P < 0.002) compared to the control group of cats. Anaemia and lymphopenia can also occur in diseases such as panleukopenia, chronic viral infections (feline viral immunodeficiency, viral leukaemia of cats), neoplasia, feline autoimmune haemolytic anaemia, etc. [4].

During the biochemical study of blood serum, special attention was paid to determining the level of total protein, albumin, globulin, bilirubin, and the activity of liver-specific enzymes – alanine aminotransferase (ALT), aspartate aminotransferase (AST), alkaline phosphatase (AP) and γ-glutamyltranspeptidase (γ-GTP).

According to N.C. Pedersen *et al*. [9], it is these indicators that are prognostic of FIP in most cases. However, the authors do not believe that their research allows confirming or refuting this diagnosis.

The results of a biochemical study of the blood serum of 12 cats with feline infectious peritonitis in comparison with the results of the control group of cats are presented in Table 2.

Table 2. Results of biochemical examination of cat blood serum with feline infectious peritonitis (M ± m, n = 12)

Indicator	Unit of measurement	Experimental group of animals		Control group	Reference values
Total protein (TP)	g/l	84.50 ± 7.28	N	76.0 ± 2.48	59-89
Albumin (ALB)	g/l	19.77 ± 1.71*	↓	31.0 ± 3.85	22-39
Globulin (GLOB)	g/l	62.50 ± 3.88*	↑	45.0 ± 4.21	21-53
Albumin/globulin ratio	–	0.36 ± 0.04***	↓	0.7 ± 0.05	< 0.4 – probable FIP 0.4-0.8 – possible FIP > 0.8 – improbable FIP
Creatinine (CREA)	μmol/l	89.39 ± 10.05	N	129.0 ± 12.90	43-165
Urea (UREA)	mmol/l	6.36 ± 0.78	N	9.8 ± 2.78	4-12.9
Total bilirubin (TBIL)	μmol/l	25.80 ± 8.82*	↑	4.0 ± 2.27	0-11
Direct bilirubin (DBIL)	μmol/l	8.80 ± 7.37*	↑	0	0-8
Alanine aminotransferase (ALT)	IU/l	40.07 ± 6.16	N	65.0 ± 5.34	10-85
Aspartate aminotransferase (AST)	IU/l	82.03 ± 24.02	↑	47.0 ± 3.19	10-56
Glucose (GLUC)	mmol/l	6.29 ± 0.39	N	4.9 ± 1.12	3.4-7.9
Alkaline phosphatase (AP)	IU/l	103.42 ± 8.12	↑	97.0 ± 1.74	6-102
GGT	IU/l	4.70 ± 1.50	N	6.0 ± 2.17	1-10

Note: * P < 0.05; **P < 0.002; *** P < 0.001, significant compared to the control group. ↓ – decrease in the indicator value; ↑ – increase in the indicator value; N – corresponds to the control limits

All 12 cats with feline infectious peritonitis showed a substantial increase in content of total and direct bilirubin levels in blood serum. Thus, the level of total bilirubin in cats of the experimental group increased by 6.5 times ($P < 0.05$) compared to the same indicator in cats of the control group. Notably, with such values of these indicators, icterus of the mucous membranes was observed only in 5 cats with FIP.

At the same time, one cat was found to have hypoglycaemia, the serum glucose concentration was 2.9 mmol/l at the reference values of 3.4-7.9 mmol/l, and two cats were found to have hyperglycaemia – the glucose level corresponded to the values of 8.8 and 9.1 mmol/l, respectively. Probably, this increase in serum glucose concentration is associated with the stressful state of cats. Therewith, in 11 cats, relative kidney-specific indicators (creatinine and urea concentrations) corresponded to the limits of reference values, while in one cat an increase in the value of these indicators was observed (creatinine – 210 mmol/l at reference values of 43-165 mmol/l; urea – 15.8 mmol/l at reference values of 4-12.9 mmol/l).

Hypoalbuminemia was observed in all the cats under study, with simultaneous development of hyperglobulinaemia. Therewith, the level of total protein in the blood serum stayed within the reference values.

The albumin/globulin ratio in the blood serum of experimental cats was also determined. Thus, in 11 sick cats, its value was < 0.4, and in one cat – 0.46. Notably, in the control group of cats that are clinically healthy, the albumin/globulin ratio in the blood serum was kept within the reference values. In the experimental group of cats, the albumin/globulin ratio in blood serum was characterized by values almost 2.0 times lower ($P < 0.001$) than in the control group of animals.

S. Felten and K. Hartmann [3] reported a 92% prognostic positive result of an albumin/globulin ratio < 0.8 based on a theoretical population with a 75% incidence of feline infectious peritonitis.

N.C. Pedersen [4] found that a low albumin/globulin ratio has a high predictive value in cats with severe clinical symptoms of feline infectious peritonitis. Furthermore, it was found that when the number of FIP cases is low, the albumin/globulin ratio is useful for excluding FIP upon differential diagnostics. However, it is not predictive for establishing this diagnosis.

According to the conducted studies, the predictive value of a positive result < 0.4 albumin/globulin ratio is 91.6%. When determining the predictive value of a positive result of the albumin/globulin ratio to the Hartmann level (< 0.8), the predictive value in the conducted study is 100%.

Having analysed the results of a biochemical blood test of cats with feline infectious peritonitis, it can be concluded that changes in these indicators are not specific.

The level of albumin, globulin, and their ratio should be considered important in the diagnosis of this disease. But these indicators are insufficient to focus on them exclusively. To diagnose feline infectious peritonitis, it is necessary to conduct a complex of clinical and laboratory tests. It is necessary to find the albumin/globulin ratio not only in the blood serum, but also in the effusion of the effusive form of feline infectious peritonitis.

According to N.C. Pedersen, M. Perron, M. Bannasch, serological studies (immunoenzyme and immunochromatographic tests) are not prognostic if they are used in monomode [4; 5; 9].

Thus, serological studies should be used only to monitor the condition of the animal with the development of coronavirus infection, and they are impractical for diagnosing feline infectious peritonitis.

In modern-day conditions, the diagnosis of feline infectious peritonitis is considered confirmed only after an immunohistochemical study of biopsies. But in practice, cats with infectious peritonitis often have a serious condition that makes anaesthesia and sampling impossible. Notably, in Ukraine, there are no veterinary laboratories that can conduct an immunohistochemical study of a biopsy to identify the causative agent of feline infectious peritonitis. That is why, in present-day realities, the diagnosis of feline infectious peritonitis is found by excluding other differential diagnoses.

Conclusions

The study of the problematic issue of establishing a diagnosis for feline infectious peritonitis has shown that the diagnosis of this disease should be comprehensive and include haematological studies.

In case of feline infectious peritonitis, changes in the morphological composition of blood and biochemical parameters are non-specific. Morphological examination of the blood of cats with infectious peritonitis revealed the development of lymphopenia, non-generative anaemia, and a decrease in the haematocrit value.

Biochemical parameters such as the determination of globulins, albumin, and bilirubin in the blood serum are of diagnostic importance for feline infectious peritonitis. Cats with infectious peritonitis have a decrease in albumin levels and an increase in globulins. Therewith, the total protein content stays within the reference limits.

The Rivalta test is a fast research method, but it only allows distinguishing exudate from transudate. Its prognostic value for infectious peritonitis is only 62.5%. Therefore, the diagnosis of feline infectious peritonitis cannot be based solely on this method. However, it should be included in the diagnostic protocol.

Diagnostic value for feline infectious peritonitis is the albumin/globulin ratio in the blood serum and in the effusion fluid (for the effusive form of infectious peritonitis). The predictive value of a positive result < 0.4 of the albumin/globulin ratio is 91.6%, and the predictive value of a positive result < 0.8 is 100%. Determination of the albumin/globulin ratio should not be used as the sole parameter for the diagnosis of feline infectious peritonitis.

Further scientific research should be aimed at investigating the clinical features of the course of feline infectious peritonitis and finding effective methods for its laboratory diagnosis. A critical issue is also the improvement of treatment measures for the development of this disease.

References

[1] André, N.M., Miller, A.D., & Whittaker, G.R. (2020). Feline infectious peritonitis virus-associated rhinitis in a cat. *Journal of Feline Medicine and Surgery Open Reports*, 6(1). doi: 10.1177/2055116920930582.

[2] Barker, E.N., & Tasker, S. (2020). Update on feline infectious peritonitis. *In Practice*, 42(7), 372-383. doi: 10.1136/inp.m3187.
[3] Felten, S., & Hartmann, K. (2019). Diagnosis of feline infectious peritonitis: A review of the current literature. *Viruses,* 11(11), article number 1068. doi: 10.3390/v11111068.
[4] Pedersen, N.C. (2014). An update on feline infectious peritonitis: Virology and immunopathogenesis. *Veterinary Journal*, 201(2), 123-132. doi: 10.1016/j.tvjl.2014.04.017.
[5] Pedersen, N.C., Perron, M., Bannasch, M., Montgomery, E., Murakami, E., Liepnieks, M., & Liu, H. (2019). Efficacy and safety of the nucleoside analog GS-441524 for treatment of cats with naturally occurring feline infectious peritonitis. *Journal of Feline Medicine and Surgery*, 21(4), 271-281. doi: 10.1177/1098612X19825701.
[6] Tasker, S. (2018). Diagnosis of feline infectious peritonitis: Update on evidence supporting available tests. *Journal of Feline Medicine and Surgery*, 20(3), 228-243. doi: 10.1177/1098612X18758592.
[7] Golovko, L., Lyons, L.A., Liu, H., Sørensen, A., Wehnert, S., & Pedersen, N.C. (2013). Genetic susceptibility to feline infectious peritonitis in Birman cats. *Virus Research*, 175(1), 58-63. doi: 10.1016/j.virusres.2013.04.006.
[8] Riemer, F., Kuehner, K.A., Ritz, S., Sauter-Louis, C., & Hartmann, K. (2016). Clinical and laboratory features of cats with feline infectious peritonitis – A retrospective study of 231 confirmed cases (2000-2010). *Journal of Feline Medicine and Surgery*, 18(4), 348-356. doi: 10.1177/1098612X15586209.
[9] Pedersen, N.C., Liu, H., Gandolfi, B., & Lyons, L.A. (2014). The influence of age and genetics on natural resistance to experimentally induced feline infectious peritonitis. *Veterinary Immunology and Immunopathology*, 162(1-2), 33-40. doi: 10.1016/j.vetimm.2014.09.001.
[10] Yin, Y., Li, T., Wang, C., Liu, X., Ouyang, H., Ji, W., Liu, J., Liao, X., Li, J., & Hu, C. (2021). A retrospective study of clinical and laboratory features and treatment on cats highly suspected of feline infectious peritonitis in Wuhan, China. *Scientific Reports*, 11(1), article number 5208. doi:10.1038/s41598-021-84754-0.
[11] Kipar, A., & Meli, M.L. (2014). Feline infectious peritonitis: Still an enigma? *Veterinary Pathology*, 51(2), 505-526. doi: 10.1177/0300985814522077.
[12] Legendre, A.M., Kuritz, T., Galyon, G., Baylor, V.M., & Heidel, R.E. (2017). Polyprenyl immunostimulant treatment of cats with presumptive non-effusive feline infectious peritonitis in a field study. *Frontiers in Veterinary Science*, 4(7). doi: 10.3389/fvets.2017.00007.
[13] Mustaffa-Kamal, F., Liu, H., Pedersen, N.C., & Sparger, E.E. (2019). Characterization of antiviral T cell responses during primary and secondary challenge of laboratory cats with feline infectious peritonitis virus (FIPV). *BMC Veterinary Research*, 15(1), article number 165. doi: 10.1186/s12917-019-1909-6.
[14] Safi, N., Haghani, A., Ng, S.W., Selvarajah, G.T., Mustaffa-Kamal, F., & Omar, A.R. (2017). Expression profiles of immune mediators in feline Coronavirus-infected cells and clinical samples of feline Coronavirus-positive cats. *BMC Veterinary Research*, 13(1), article number 92. doi: 10.1186/s12917-017-1019-2.
[15] Yousuf, J., Bhat, R.A., Dar, S.H., Shafi, A., Irshad, S., Yatoo, M.I., Parrah, J.U., Muhee, A., & Mir, A.Q. (2022). A review on the diagnosis of feline infectious peritonitis. *Applied Veterinary Research*, 1(1), article number e2022005. doi: 10.31893/avr.2022005.
[16] Pedersen, N.C., Eckstrand, C., Liu, H., Leutenegger, C., & Murphy, B. (2015). Levels of feline infectious peritonitis virus in blood, effusions, and various tissues and the role of lymphopenia in disease outcome following experimental infection. *Veterinary Microbiology*, 175(2-4), 157-166. doi: 10.1016/j.vetmic.2014.10.025.

Морфологічні та біохімічні зміни показників крові в котів з інфекційним перитонітом

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Анотація. Інфекційний перитоніт котів – це захворювання котячих, збудником якого є мутант коронавірусу, що призводить до загибелі молодих тварин. На сьогодні цю патологію вважають невиліковною, а тому вона потребує детального вивчення. Метою дослідження було встановлення особливостей клінічного прояву та гематологічних показників у котів за інфекційного перитоніту. Представлено результати клініко-лабораторного дослідження 12 котів, віком від 6 місяців до 3 років, у яких було діагностовано інфекційний перитоніт ефузивної та сухої форм. У роботі використовували клінічні, лабораторні та візуальні методи дослідження. Лабораторний аналіз включав дослідження морфологічних і біохімічних показників крові, цитологічне дослідження випоту з абдомінальної й плевральної порожнин, пробу Рівальта. В результаті цитологічного дослідження випоту із

зазначених порожнин виявлено високу концентрацію клітин, скупчення макрофагів, фагоцитоз нейтрофілів, еритроцити в усьому полі зору. Встановлено, що прогностичність проби Рівальта за інфекційного перитоніту котів становить 62,5 %. За гематологічного дослідження в усіх хворих тварин діагностовано анемію, лімфопенію, гіпоальбумінемію, гіперглобулінемію, гіпербілірубінемію, підвищення активності відносноспецифічних для печінки ферментів (аспартатамінотрансферази, лужної фосфатази). У двох тварин відзначали тробмоцитопенію, а в одного кота встановлено підвищення в крові маркерів функціонального стану нирок (креатиніну, сечовини). Важливим діагностичним показником слід також вважати альбумін/глобулінове співвідношення в сироватці крові. Так, за інфекційного перитоніту котів цей показник має бути < 0,4. У 11 хворих котів це співвідношення характеризувалося значеннями нижчими за 0,4, а у однієї тварини цей показник становив 0,46. В цілому, отримані дані морфологічного та біохімічного аналізу крові не є специфічними для інфекційного перитоніту котів, а тому з діагностичною метою рекомендуємо їх комплексне дослідження. Проведена об'єктивна оцінка доступних методів лабораторної діагностики сприятиме створенню діагностичного протоколу за інфекційного перитоніту котів

Ключові слова: коронавірусна інфекція, клінічні та гематологічні дослідження, проба Рівальта, цитологічне дослідження