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Changes in haematological parameters in case of oral cavity pathologies in dogs

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Abstract. Diseases of the oral cavity in dogs are common all over the world and require a comprehensive approach to the diagnosis and treatment of such patients. Leukocytosis is often noted in the blood of animals with chronic diseases of the oral cavity, which indicates the activation of the body's immune response to the progressive development of the pathological process or its possible exacerbation. The purpose of this study involved a comprehensive assessment of morphological and biochemical parameters of blood in dogs with oral diseases to establish their connection with the pathological process. Dogs with an infectious and inflammatory process in the oral cavity for periodontitis, stomatitis, and calculus were selected for the study. Standard laboratory methods were used to determine the morphological parameters of blood – the number of red blood cells, white blood cells and platelets, and biochemical parameters – the content of haemoglobin, glucose, creatinine, urea, the activity of aminotransferases, gamma-

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glutamyltranspeptidase, alkaline phosphatase, etc. In addition, an X-ray method was used to diagnose the condition of the oral cavity organs in sick dogs. Based on the data obtained, it was found that diseases of the oral cavity in these animals were accompanied by significant changes in certain morphological and biochemical parameters of the blood, which may indicate a systemic reaction of the body to the pathological process. In particular, leukocytosis (for stomatitis and periodontitis), hypochromemia (for calculus), a decrease in the value of haematocrit (for periodontitis), thrombocytopenia (for all pathologies), and an increase in its plasma activity of aspartate aminotransferase (for stomatitis and periodontitis), a decrease in the activity of alkaline phosphatase (for stomatitis), a decrease in the activity of gamma-glutamyltranspeptidase (for calculus) and an increase (for periodontitis), hyperglycemia and hyperazotemia (for stomatitis and periodontitis) were noted. The established changes in haematological parameters are a reflection of the development of a pathological process in the oral cavity of dogs and can play a key role in diagnosing and predicting the course of these diseases, choosing the optimal treatment strategy and monitoring its effectiveness

Keywords: periodontitis; calculus; stomatitis; gingivitis; epulis; morphological and biochemical studies

Introduction

Diseases of the oral cavity in dogs are one of the most significant problems in veterinary medicine that need to be solved with the use of scientifically based therapeutic and preventive measures. They can occur for various reasons, such as negligent care of teeth and gums, damage due to mechanical, chemical, and thermal factors, unbalanced feeding, genetic factors, etc. Because of this, dogs can develop diseases such as calculus, stomatitis, periodontitis, gingivitis and others, which can lead to pain, discomfort, and refusal of food. In general, the effect of oral diseases on the body is a multicomponent and complex process that includes both local inflammatory reactions and the possible penetration of bacterial toxins and pathogens into the systemic circulation, which leads to activation of the immune system. In addition, an imbalance of the oral microflora can lead to increased levels of anti-inflammatory cytokines, which leads to the development of chronic inflammation and contributes to changes in haematological parameters. L. Aresu & S. Benali (2020) have proven a link between chronic oral pathologies and an increased risk of cardiovascular diseases, diabetes mellitus, and the effect on overall immune status, which underlines the importance of studying haematological changes.

In recent years, there has been a tendency to increase the number of cases of non-infectious pathologies in dogs, of which a large percentage are diseases in the oral cavity. B. Smith *et al.* (2020) found that among the registered pathologies, dental diseases, in particular periodontitis, are most common. The main causes of their occurrence are mechanical fractures of teeth and carious lesions, complicated by the development of pulpitis with signs of necrosis. U. Voloboieva *et al.* (2023) found that among the nosological forms in dentistry, dogs most often had plaque, periodontal disease, caries, abnormal tooth decay and their absence. In the structure of morbidity, periodontitis accounted for 60-80%, calculus was noted in 30-50% of cases, the absence of teeth was registered in 20-30% of patients, gingivitis

and tooth decay were diagnosed in 15-20%, and the presence of a neoplasm was confirmed in 3-10% of patients.

R. Wadia (2021) noted that, for example, periodontitis is registered 5 times more often in small breeds of dogs with low weight (< 6.5 kg) than animal breeds with larger sizes and weights (> 25 kg). At the same time, the age of animals and excess weight contribute to the development of this disease. Despite the importance of the problem, a large number of dog owners do not pay due attention to the dental health of their pets, which often leads to an aggravation of the situation. In particular, E. Cunha *et al.* (2022) found out that the problem of dental diseases in animals becomes particularly relevant due to their significant impact on the overall health and quality of life of animals. The authors have proven that oral infections affect the functioning of the digestive system, and can also cause a threat to the cardiovascular system and the immune status of the body.

Therefore, research aimed at understanding the epidemiology, aetiology, diagnosis, therapy and prevention of dental diseases in dogs are very relevant and important. U. Voloboieva *et al.* (2023) found that dental problems are diagnosed in a large part of the dog population and are the result of various factors, including feeding, hygiene, and genetic factors. A. Freeman (2021) proved the importance of intraoral radiography in dogs and cats, clarified the main methods and provided useful tips necessary for successful radiography. Thus, dental diseases in dogs can affect blood balance and performance through various mechanisms, such as inflammatory processes and bacterial infections. Therefore, the purpose of the study was to analyse changes in indicators blood in dogs for the most common dental diseases (calculus, periodontitis, stomatitis) and establish their clinical significance for use in the diagnosis and treatment of such patients.

Literature Review

L. Glickman *et al.* (2009) found that oral diseases in dogs are a serious problem that often requires a comprehensive diagnostic and therapeutic approach. The oral cavity is an important component of the overall health of the animal and any pathological process in the oral cavity can affect the general condition of the animal and its quality of life. Along with the clinical symptoms that can be detected by the owner, changes in haematological parameters serve as important indicators of the presence and severity of oral pathologies in dogs. Diagnosis of oral diseases in dogs can be difficult because animals do not always show obvious symptoms of discomfort or pain.

M. Martínez-García & E. Hernández-Lemus (2021) proved that dental diseases especially common in dwarf dog breeds. In addition, the researchers drew attention to the variety of pathologies that are diagnosed in the oral cavity. These pathologies are often characterised by the development of pain and/or the manifestation of systemic and local infection. However, the vast majority of these pathologies have an asymptomatic course or almost no clinical symptoms. Therefore, they are usually diagnosed at a late stage of the disease. Consideration of the specifics of the pathogenesis of these pathologies will help the practising veterinarian improve the effectiveness of their treatment.

C. Garcia *et al.* (2023) found that one of the most typical changes in periodontitis and stomatitis is leukocytosis – an increase quantity of white blood cells in the studied blood samples. D. O'Neill *et al.* (2021) also proved that in periodontitis and stomatitis, there is an increase in the number of white blood cells in accordance with the activation of the inflammatory response in response to the development of an infectious process or inflammation in the oral cavity. White blood cells, in particular neutrophils, become more active in such conditions,

which leads to a significant increase in their number in the blood. Besides, the ratio of different white blood cell subtypes may also vary. For example, a large number of immature neutrophils, called rod neutrophils, can be noticeable in massive inflammatory processes in the oral cavity. Changes in the concentration of other white blood cells, such as lymphocytes and monocytes, are usually less pronounced compared to an increase in the number of neutrophils. When evaluating a general blood test, it is necessary to pay attention not only to changes in white blood parameters (white blood cells), but also to red blood indicators.

Quantitative changes in red blood cells in the blood are also noted in dogs with diseases of the oral cavity, which indicates a different aetiology of the pathological process that occurs in the animal's body. A. Zacher & S. Marretta (2013) found that one of the typical changes is an increase in the number of red blood cells (erythrocytosis) or their decrease (erythrocytopenia). This can be caused by various factors, including general inflammation, dehydration, blood loss, and other concomitant pathological processes. For example, in cases of a significant area of inflammation or infectious diseases in the oral cavity, the body may react by increasing the number of red non-nuclear cells in the blood, directing them to damaged tissues to provide the necessary nutrients and oxygen. C. Garcia *et al.* (2023) found that in the general blood test of dogs, changes in haemoglobin levels and haematocrit. Thus, a decrease in the level of haemoglobin below the minimum value of the norm indicates anaemia, which develops due to blood loss, a decrease in the production of red blood cells or their increased destruction. On the other hand, an increase in haemoglobin levels can occur when the body is dehydrated or under other conditions that lead to blood clots.

However, it is important to consider that changes in the red blood cells can be non-specific and occur not only due to the development of diseases of the oral cavity. They can be associated with other diseases or conditions, such as haemorrhagic diseases, chronic kidney failure, or caused by physiological factors such as stress or exercise. Thus, the analysis of red blood cells in dogs with oral diseases can help assess the general condition of the animal and identify possible complications resulting from these pathological processes. However, for accurate diagnosis and reasonable treatment, it is important to conduct a comprehensive approach that includes not only haematological studies, but also other methods and clinical examination.

G. Armitage & M. Cullinan (2010) proved that in the study of dogs with oral diseases, the analysis of biochemical parameters of blood is of great importance, since this type of study provides additional information about the functional state of organs and systems of the body as a whole. Pathological processes that occur in the oral cavity can affect various organs and systems due to the general influence of inflammatory factors, the development of an immune response, and metabolic disorders. Thus, the analysis of blood biochemical parameters helps to identify the systemic consequences of diseases of the oral cavity and determine further medical tactics.

C. Wallis & L. Holcombe (2020) found that among the biochemical indicators that are usually analysed in the blood of dogs with diseases of the oral cavity, changes in the activity of enzymes are manifested, in particular, amylases and alanine aminotransferases, development of hypo- and dysproteinemia, violation of neutralisation and elimination of end products of nitrogen metabolism and electrolyte deficiency. An increase in the activity of amylase and alanine aminotransferase in the blood may indicate tissue damage in the oral cavity, which is characteristic of various diseases, such as periodontitis and cancer. Besides, J. Pereira Dos Santos *et*

al. (2019) found that an increase in total protein content, in particular, gamma globulins, may indicate an active immune response of the body during infectious or inflammatory processes. Alkaline phosphatase hyperfermentemia in dogs can be an indicator of various pathological changes, including diseases of the oral cavity.

Alkaline phosphatase is a non-specific enzyme that is present in many organs and tissues of the body, in particular, in bone tissue, liver, intestines, and kidneys. Alkaline phosphatase hyperfermentemia can manifest itself for various reasons. Therefore, the level of its activity can have diagnostic and prognostic significance when considering diseases of the oral cavity. Based on the results of the study, D. O'Neill *et al.* (2021) proved that in the case of diseases of the oral cavity, alkaline phosphatase hyperfermentemia is registered, which is several times higher than the normal value. Such deviations in the activity of the enzyme can be caused by damage to the liver or bone tissue due to the development of generalised inflammation, infection, or other pathological processes. Thus, the increased activity of alkaline phosphatase is only one of the biochemical indicators that can be used in combination with other clinical and laboratory markers to assess the functional state of the animal's body.

However, it is important to note that changes in blood biochemical parameters can be non-specific and depend on many factors, such as the stage of the disease, the presence of complications and individual physiological characteristics of the patient. In addition, it was important to conduct a differential diagnosis, considering other possible causes of changes in biochemical parameters that are not related to the pathology of the oral cavity. The study considered both morphological changes in native blood in dogs and biochemical parameters associated with diseases of the oral cavity. The issues of pathophysiological mechanisms that arise as a result of haematological changes in dental diseases in dogs are covered in detail. This will contribute to the best understanding the mechanisms of development of pathological processes and adaptive response of the body due to the occurrence of diseases oral cavity and the development of a strategy for further research in this area. In addition, the analysis of haematological changes in oral diseases in dogs will help to invent new opportunities for their early diagnosis, criteria for monitoring diseases and choosing the optimal treatment.

Materials and Methods

The study was conducted during January-November 2023 at a private veterinary clinic "Alden-Vet" (Kyiv, Ukraine). To form groups, 15 animals of different breeds (Yorkshire terrier, Chihuahua, Maltese lapdog, and cross-breed) and the same age category were selected. The first group included dogs with diagnosed calculus (n = 15), the second – with stomatitis (n = 15), and the third – animals with periodontitis (n = 15). The control group included clinically healthy dogs (n = 15). To establish the diagnosis, a detailed history of the animals' life and a general clinical examination were collected. As additional diagnostic tests, blood samples were taken from experimental animals of all groups for the analysis of morphological and biochemical parameters. Before blood collection, the animals were kept on a 6-hour starvation diet.

For a general clinical blood test, biological samples were taken in tubes with an anticoagulant – ethylenediaminetetraacetic acid and a veterinary haematology analyser "Heska Element HT" (USA) was used. Using this analyser, such blood parameters as: the number of red blood cells, white blood cells and platelets, haemoglobin content, haematocrit level were determined. In the case of biochemical studies, the blood was stabilised with heparin, after which it was centrifuged for 10-15 minutes at a

speed of 1,500-2,500 thousand rpm. At the end of the centrifugation procedure, a supernatant fluid was selected – blood plasma, in which biochemical parameters were determined: activity of aofspartataminotransferase (AST), alanine aminotransferase (ALT), and alkaline phosphatase (LF), as well as the concentration of glucose, creatinine and urea nitrogen. These parameters were measured using an automatic biochemical express blood analyser "Fujifilm DRI-CHEM NX600" (Japan), which operates on the principle of "dry chemistry" using slides and is intended for veterinary clinics.

Periodontal tests and evaluation of periodontal pockets were performed using a diagnostic periodontal probe TYPE 4 (WHO) DDI-10-p5 (Ukraine). Before starting the study, outpatient maps of dogs were analysed to identify possible previously recorded changes in blood parameters that would indicate chronic processes. After that, the material was selected. For a detailed examination and periodontal tests, the animals were sedated using the drug Dexdomitor from Orion Pharma (France). This drug belongs to the category of sedatives with a strong selective alpha$_2$-adrenomimetic. A 1% lidocaine solution (Ukraine) was used to block the upper and lower jaw. The blockade was performed by blocking the conduction of a nerve impulse along nerves such as *n. Maxilla* and *n. Mandibula*. In addition, another diagnostic method was used to examine patients – radiographic, which was performed using the X-MIND Unity X-ray system (Japan) and the SOPIX 2 radiovisiograph (France).

Scientific research involving animals met the requirements of the European Convention for the protection of vertebrates used for experimental and scientific purposes (1986) and the Law of Ukraine No. 3447-IV "On the Protection of Animals from Cruelty" (2006). All necessary animal interventions were carried out in compliance with ARRIVE recommendations, without violating the guidelines of EU directive 2010/63/EU (2010) on the protection of animals used for scientific purposes.

Statistical processing of the results of the study of haematological parameters was carried out using a personal computer, in the programme "BAF – Veterinary Medicine" and individual dental records of patients. To determine the statistical reliability of the detected differences between haematological parameters in dogs in separate experimental groups, the Student's t-test was used. The authors were guided by the fact that the differences between the two compared indicators from two different samples were statistically significant at $P < 0.05$, $P < 0.01$, or $P < 0.001$.

Results and Discussion

According to the results of the clinical examination of animals, the spread of various pathologies in the oral cavity was established (Fig. 1), which are most often diagnosed in dogs.

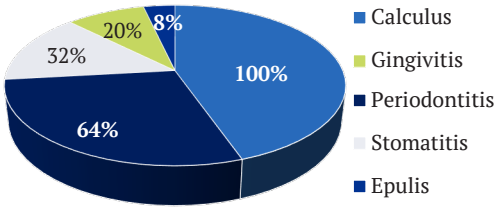

Figure 1. Spread of oral pathologies in dogs
Note: *the sectors of the chart of different colours indicate the relative number of cases of diseases with different pathological processes in the oral cavity of dogs*
Source: *developed by the authors*

Figure 1 shows that 100% of the dogs under study had calculus (the presence of calculus plaque of varying degrees), 64% of the animals were diagnosed with periodontitis, and 32% of patients with stomatitis. Thus, among the pathological lesions of the oral cavity that are most often found in dogs, calculus, stomatitis (Fig. 2) and periodontitis should be noted.

During the visual assessment of the condition of the oral mucosa and gums, gingivitis, epulis (Fig. 3) and epuloid formations (Fig. 4) were diagnosed in experimental dogs somewhat less often than other pathologies. Detailed radiography was used to assess periodontal disease and reveal its existing lesion, which is reflected in the reduction of bone structure and the absence of periodontal ligament in periodontitis (Fig. 5).

Figure 2. Clinical manifestations of calculus plaque and stomatitis in dogs
Note: *1 – calculus; 2 – stomatitis*
Source: *developed by the authors*

Figure 3. Clinical manifestations of epulis and gingivitis in dogs
Note: *1 – epulis; 2 – gingivitis*
Source: *developed by the authors*

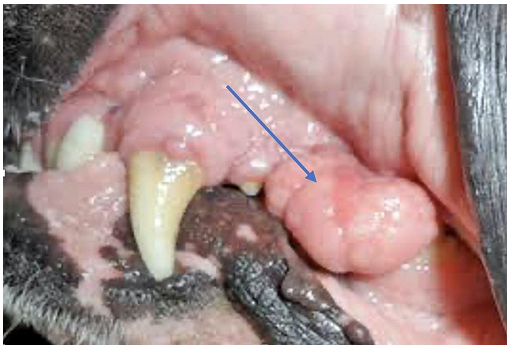

Figure 4. Epuloid formation in dogs
Note: *the arrow indicates a pathological process – epuloid formation*
Source: *developed by the authors*

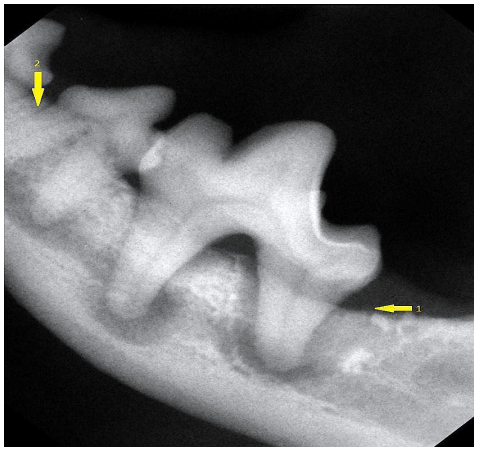

Figure 5. Dental radiography of periodontitis in the development of periodontitis
Note: *1 – reduction of bone structure with the absence of periodontal ligament; 2 – normal periodontal ligament*
Source: *developed by the authors*

Table 1 presents the results of a clinical analysis of native blood in experimental dogs for the most common diseases of the oral cavity – calculus, stomatitis, and periodontitis. According to Table 1, it was noted that in dogs of the second (with stomatitis) and third (with periodontitis) experimental groups, the number of white blood cells (leukocytosis) increased, respectively,

by 88.6% (P < 0.001) and by 138.0% (P < 0.001) compared to animals of the control group. In all three study groups, a decrease in the number of platelets (thrombocytopenia) (p < 0.001) was recorded in the native blood of dogs, respectively by 23%, 32%, and 40% compared to the animals of the control group. In the blood of dogs of the third experimental group, a significant decrease in the haematocrit value by 19.4% was noted (P < 0.001), and in the blood of dogs of the first experimental group (with calculus) – a decrease in haemoglobin content by 16.7% (P < 0.05).

Table 1. Changes in morphological and other indicators of Native blood in pathologies of the oral cavity in dogs (M ± m, n = 15)

Blood counts, units of measurement	Pathologies of the oral cavity			Control group
	Group 1 (dogs with calculus plaque)	Group 2 (dogs with stomatitis)	Group 3 (dogs with periodontitis)	
White blood cells, 10^9/L	14.1 ± 2.3	23.2 ± 1.85***	29.3 ± 1.23***	12.3 ± 1.03
Red blood cells, 10^{12}/L	5.5 ± 0.8	3.95 ± 0.92	5.35 ± 1.2	5.66 ± 0.9
Haematocrit, %	42.0 ± 3.51	46.6 ± 4.2	28.6 ± 2.52***	48.0 ± 1.3
Haemoglobin, g/L	135.0 ± 6.82*	158.0 ± 10.45	145.0 ± 12.2	162.0 ± 11.6
Platelets, 10^9/L	323.0 ± 12.4***	286.0 ± 14.33***	253.0 ± 16.2***	420.0 ± 17.44

Note: **P < 0.05; ***P < 0.001, the difference is significant compared to the animals of the control group*
Source: *developed by the authors*

The results of the study coincide with the data obtained by D. Penoni *et al.* (2019). In particular, the haemoglobin content in dental diseases in dogs remained almost unchanged. However, the researchers pointed out that the development of local inflammation has a number of consequences related to the disease. Thus, in contrast to healthy animals, leukocytosis was recorded in patients with periodontitis, and a significant increase in the parameters of other haematological parameters in the blood, which indicated the development of systemic inflammation. Similar patterns were described by G. Cecoro *et al.* (2020).

In this regard, it is worth noting that there is clinical evidence of the involvement of the development of periodontitis in the pathogenesis of systemic inflammation. However, a causal relationship has yet to be proven. N. Ferlazzo *et al.* (2021) found that a decrease in the values of systemic inflammatory biomarkers after periodontal interventions leads to a reduced risk of cardiovascular diseases, in particular, in the form of endothelial dysfunction. However, there is still insufficient evidence for the effect of periodontal interventions on reducing the development of cardiovascular pathologies in the long term. The effect on atherosclerotic vascular diseases remains unclear, so further research is needed. Table 2 presents a correlation analysis to determine the dependence of the results obtained in the context of oral pathologies and quantitative parameters of haematological parameters.

Table 2. Analysis of the correlation between changes in haematological parameters and the development of dental diseases (M ± m, n = 15)

Indicator	Correlation of the indicator with calculus	Correlation of the indicator with stomatitis	Correlation of the indicator with periodontitis
White blood cells, 10^9/L	+0.25 (P < 0.05)	+0.35 (P < 0.01)	+0.40 (P < 0.01)

Table 2. Continued

Indicator	Correlation of the indicator with calculus	Correlation of the indicator with stomatitis	Correlation of the indicator with periodontitis
Red blood cells, 10^{12}/L	-0.15 (P > 0.05)	-0.20 (P < 0.05)	-0.28 (P < 0.01)
Haematocrit, %	-0.18 (P > 0.05)	-0.22 (P < 0.05)	-0.27 (P < 0.01)
Haemoglobin, g/L	-0.20 (P > 0.05)	-0.25 (P < 0.05)	-0.30 (P < 0.01)
Platelets, 10^9/L	-0.12 (P > 0.05)	-0.18 (P < 0.05)	-0.22 (P < 0.05)

Note: *the relationship between changes in the parameters of morphological and other blood parameters and pathologies of the oral cavity in dogs is shown*
Source*: developed by the authors*

Table 2 shows that there is a negative correlation between the level of almost most haematological indicators, except for the number of white blood cells, and the presence of calculus, stomatitis, and periodontitis in dogs. This indicates a slight influence of the studied pathologies of the oral cavity on the morphological parameters of blood. Stomatitis (+0.35; P < 0.01) and periodontitis (+0.40; P < 0.01) showed an increase in the number of white blood cells in the native blood. Therefore, it can be argued that with these dental pathologies, the development of inflammatory processes progresses. At the same time, the presence of calculus (+0.25) in dogs was accompanied by the development of leukocytosis, although with a slightly lower significance coefficient (P < 0.05).

Thus, pathologies of the oral cavity, especially stomatitis and periodontitis, show a specific effect on the dynamics of some of the studied haematological indicators, causing a significant decrease in the haematocrit and platelet count, and an increase in the number of white blood cells compared to that in animals of the control group. In the case of the development of calculus in the oral cavity of dogs, thrombocytopenia developed and a decrease in haemoglobin levels (hypochromemia) was observed. Overall, these results confirm the importance of monitoring morphological and other haematological parameters in the treatment of dogs with inflammatory diseases of the oral cavity to prevent the occurrence of systemic complications. In addition, a study of the influence of the most common dental diseases on the quantitative parameters of biochemical parameters of blood plasma in dogs was conducted (Table 3).

Table 3. Changes in biochemical parameters in the blood plasma of dogs in diseases of the oral cavity (M ± m, n = 15)

Indicator	Pathologies of the oral cavity			Control group
	Group 1 (dogs with calculus plaque)	Group 2 (dogs with stomatitis)	Group 3 (dogs with periodontitis)	
Aspartate aminotransferase, U/L	40.3 ± 1.02	56.3 ± 2.2***	72.0 ± 6.4***	40.0 ± 2.3
Alanine aminotransferase, U/L	89.9 ± 6.3	82.0 ± 8.2	90.0 ± 10.3	90.0 ± 6.04
Alkaline phosphatase, U/L	60.0 ± 9.04	45.4 ± 2.3***	62.0 ± 3.3	62.3 ± 4.2
Gamma-glutamyltranspeptidase, U/L	1.2 ± 0.4**	5.5 ± 0.8	9.2 ± 1.02***	5.3 ± 1.2
Glucose, mmol/L	4.60 ± 1.20	6.32 ± 1.1*	7.36 ± 0.90**	4.6 ± 1.3
Creatinine, μmol/L	68.0 ± 7.6	186.6 ± 12.3***	210.0 ± 14.3***	70.0 ± 3.8

Table 3. Continued

Indicator	Pathologies of the oral cavity			Control group
	Group 1 (dogs with calculus plaque)	Group 2 (dogs with stomatitis)	Group 3 (dogs with periodontitis)	
Urea nitrogen, mmol/L	5.0 ± 0.8	10.2 ± 2.2***	12.0 ± 2.2***	5.3 ± 0.9

Note: *1. *P < 0.05; **P < 0.01; ***P < 0.001 compared to animals in the control group*
Source: *developed by the authors*

Analysis of the results in Table 3 showed that in the blood plasma of dogs of the second (with stomatitis) and third (with periodontitis) experimental groups, aspartate aminotransferase activity increased by 40.8% (P < 0.001) and 80% (P < 0.001), creatinine concentrations increased by 166.6% (P < 0.001) and 200% (P < 0.001), and urea nitrogen by 92.5% (P < 0.001) and 126.4% (p < 0.001), respectively, compared to the control. Along with this, in the blood plasma of dogs of the second (with stomatitis) and third (with periodontitis) experimental groups, an increase in glucose concentration (hyperglycemia) was recorded, respectively, by 37.4% (P < 0.05) and by 60.0% (P < 0.01) in relation to the control. It is worth noting that in the blood plasma of dogs of the first experimental group (with calculus), a decrease in the activity of gamma-glutamyltranspeptidase was observed by 77.4% (P < 0.01), while in the blood plasma of dogs of the third experimental group (with periodontitis), its hyperfermentemia was noted by 73.6% (P < 0.001).

The established patterns of changes in biochemical parameters in the blood plasma of dogs in various pathologies indicate: the presence of pronounced destructive changes in the cells of the oral mucosa and other interrelated tissues and organs, the predominance of catabolic processes due to the development of inflammation and stress reaction of the body, which provokes the occurrence of tension in carbohydrate and nitrogen metabolism with the development of stomatitis; similar patterns, but with deeper destructive changes in periodontal tissues, which negatively affected the functioning of the entire body, including the liver, kidneys, and muscle tissue, with corresponding changes in biochemical parameters were noted for periodontitis; due to the development of calculus in the oral cavity of dogs, hypoenzyme gamma-glutamyltranspeptidase developed, which may indicate disorders in the metabolism of amino acids, disorders in the metabolism of glutathione – an important antioxidant that protects cells from oxidative stress, and systemic processes – negative changes in the functioning of the hepatobiliary system with the phenomenon of cholestasis and pancreas. In addition, a correlation analysis of the results of the study was carried out to determine the relationship between changes in the biochemical parameters of blood plasma in dogs and existing pathologies of the oral cavity (Table 4).

Table 4. Correlation analysis between oral pathologies and changes in biochemical parameters in canine blood plasma (M ± m, n = 15)

Indicator	Correlation of the indicator with calculus	Correlation of the indicator with stomatitis	Correlation of the indicator with periodontitis
Aspartate Aminotransferase, U/L	+0.20 (P < 0.05)	+0.18 (P < 0.05)	+0.28 (P < 0.01)
Alanine aminotransferase, U/L	+0.22 (P < 0.05)	+0.20 (P < 0.05)	+0.30 (P < 0.01)

Indicator	Correlation of the indicator with calculus	Correlation of the indicator with stomatitis	Correlation of the indicator with periodontitis
Alkaline phosphatase, U/L	+0.24 (P < 0.05)	+0.22 (P < 0.05)	+0.32 (P < 0.01)
Gamma-glutamyltranspeptidase, U/L	+0.28 (P < 0.05)	+0.25 (P < 0.05)	+0.35 (P < 0.01)
Glucose, mmol/L	+0.25 (P < 0.05)	+0.22 (P < 0.05)	+0.30 (P < 0.01)
Creatinine, μmol/L	+0.22 (P < 0.05)	+0.20 (P < 0.05)	+0.28 (P < 0.01)
Urea nitrogen, mmol/L	+0.20 (P < 0.05)	+0.18 (P < 0.05)	+0.26 (P < 0.01)

Note: *relationship between variable indicators for oral pathologies*
Source: *developed by the authors*

Table 4 shows that there is a positive correlation between the activity of aspartate aminotransferase in the blood plasma of dogs and pathologies of the oral cavity of dogs (P < 0.05; P < 0.01; P < 0.05), in particular: with stomatitis (+0.18), with periodontitis (+0.28), with calculus (+0.20). A close correlation was established between the activity of alanine aminotransferase and periodontitis (+0.30) with a high significance factor (P < 0.01). This can be explained by a certain sensitivity of these indicators to the development of dental pathology in dogs. A high degree of correlation was observed for the activity of alkaline phosphatase (+0.32) and the development of periodontitis (P < 0.01), which indicates the effect of inflammation on metabolic processes that may be associated with changes in bone tissue or liver.

According to the activity of gamma-glutamyltranspeptidase in the blood plasma of dogs, the highest correlation values were noted among all the studied indicators: from +0.25 to +0.35. The closest correlation was recorded for the content of gamma-glutamyltranspeptidase in periodontitis (+0.35; P < 0.01) in dogs, which confirms the activation of liver function and a possible increase in oxidative stress in this disease. In the case of periodontitis, the closest correlations in glucose content were found in the blood plasma of dogs (+0.30; P < 0.01), creatinine (+0.28; P < 0.01), and urea nitrogen (+0.26; P < 0.01). It can be assumed that the occurrence of hyperglycemia is a consequence of the body's stress response to inflammation and the result of the mobilisation of carbohydrates from the depot, and an increase in the concentration of creatinine and urea nitrogen indicates the activation of the final stages of protein metabolism and functional disorders of the kidneys and liver.

According to the results obtained, the authors state the importance of a comprehensive approach to the diagnosis and control of patients with oral pathologies, since such diseases can have a significant impact on the general condition of the body and provoke the development of complications from other organs and systems, in particular, stress in the functioning of the liver, kidneys, general stress, and metabolic disorders. It is important to consider these changes when diagnosing and treating dogs with oral diseases to ensure their well-being. A. Cabała *et al.* (2006) found that oral infections, especially periodontitis can affect the mechanisms of pathology development and the course of a number of systemic diseases, namely: cardiovascular and cerebrovascular, atheromatous peripheral vascular disease, bacterial pneumonia, diabetes mellitus, osteoporosis, or cause an unfavourable outcome of pregnancy. D. Penoni *et al.* (2019) indicated a two-way association between chronic periodontitis and

systemic bone loss. The researchers proved that osteoclast regulation is influenced by a number of cytokines and secondary messengers produced during the chronic process.

In this context, L. Chaushu *et al.* (2021) described the effect of periodontal infection on changes in blood biochemical parameters that coincide with the results obtained during this study, namely hyperfermentemia of alkaline phosphatase, increased uric acid or creatinine levels. This can be an indicator of kidney problems that occur against the background of inflammatory processes in the oral cavity, for example, stomatitis or periodontitis. Hyperglycemia in dogs can occur due to stress accompanying disorders in the oral cavity, or as a result of the development of diseases that can affect appetite. Hyperfermentemia of aspartate and alanine aminotransferases in the blood plasma of sick animals may indicate liver and muscle damage, which coincides with the conclusions and results described in this paper. In the case of oral diseases, this may be conditioned by inflammatory processes or infections that affect the general condition of the body (Polkowska *et al.*, 2014).

After evaluating and comparing changes in haematological parameters in dogs with various pathologies of the oral cavity, it can be noted that with the development of periodontitis and stomatitis, similar patterns are observed regarding deviations in the parameters of morphological and biochemical parameters of blood, which indicate the development of not only local pathological processes, but also those that have a generalised nature of changes from other organs and tissues. A more complex nature of changes in the studied haematological parameters occurs with the development of periodontitis. In the presence of calculus in dogs, the nature of changes in the haematological profile of blood is somewhat different from the previous two pathologies. In particular, there are violations in the metabolism of amino acids, the functioning of red bone marrow, which affects the synthesis of haemoglobin and platelet formation, and disorders in the functioning of the hepatobiliary system.

This paper presents the results of the study of the most common forms of oral pathologies in dogs and proves that the analysis of haematological parameters is an important diagnostic tool in identifying pathological processes that may also have a latent course and be not obvious during the clinical examination of the patient. Thus, the determination of specific haematological changes occurring in dogs for oral pathologies is an important aspect in veterinary medicine for the early diagnosis of these diseases and the possible occurrence of complications from other organs and systems of the body.

Conclusions

The study of the influence of oral pathologies on the haematological parameters of dogs demonstrates a significant effect on the general condition of the body. Infectious and inflammatory processes in the oral cavity, such as periodontitis, stomatitis, calculus can cause systemic changes in the blood and in other organs and tissues (liver, pancreas, red bone marrow, kidneys, and muscles), primarily due to the reaction of the immune system. After analysing statistical data on the spread of oral diseases in dogs, the following was found: 100% of the studied animals had calculus plaque, 64% – periodontitis, and 32% – stomatitis. Gingivitis, epulis, and epuloid formations were somewhat less commonly diagnosed. According to the results of the study of the haematological profile in dogs, a number of patterns were identified for the most common pathologies of the oral cavity. Thus, patients with diagnosed calculus plaque developed hypochromemia, thrombocytopenia, and gamma-glutamyltranspeptidase

hypoenzyme. Leukocytosis, thrombocytopenia, aspartate aminotransferase hyperenzymentemia, alkaline phosphatase hypoenzyme, hyperglycemia, and hyperazotemia were reported in dogs with stomatitis. And in the case of periodontitis, leukocytosis, a decrease in hematocrit, thrombocytopenia, hyperenzymentemia of aspartate aminotransferase and gamma-glutamyltranspeptidase, hyperglycemia, and hyperazotemia were noted in animals. The described patterns indicate a similarity of changes in haematological parameters in the last two diseases with small discrepancies. Although, the degree of manifestation of these disorders was more pronounced in periodontitis compared to stomatitis. Considering the above-mentioned changes in haematological parameters, it can be argued that regular blood monitoring of patients with oral pathologies is appropriate and serves as an additional tool for assessing the severity and activity of the inflammatory process. Treatment of inflammatory diseases of the oral cavity should include not only local therapy, but also comprehensive approaches to reduce the risk of negative systemic consequences. Consequently, pathologies of the oral cavity have not only a local, but also a systemic effect, which is manifested in changes in haematological parameters. This indicates the importance of timely diagnosis and treatment of these diseases using established patterns and sensitive haematological parameters to prevent the occurrence of complications and properly maintain the functional state of the body.

Further research will be aimed at evaluating the effectiveness of methods for preventing pathological processes in the oral cavity of dogs. It is also planned to conduct comprehensive studies to identify the early impact of oral lesions on other body systems.

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None.

Conflict of Interest

None.

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Зміни гематологічних показників за патологій ротової порожнини в собак

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Анотація. Хвороби ротової порожнини в собак поширені в усьому світі та потребують комплексного підходу в питаннях діагностики та лікування таких хворих. У крові тварин з хронічними захворюваннями органів ротової порожнини часто відмічають лейкоцитоз, що свідчить про активацію імунної відповіді організму на прогресуючий розвиток патологічного процесу або можливе його загострення. Метою цього дослідження було проведення комплексної оцінки морфологічних і біохімічних показників крові в собак з хворобами ротової порожнини для встановлення їх зв'язку з патологічним процесом. Для дослідження відбирали собак з інфекційно-запальним процесом у ротовій порожнині за пародонтиту, стоматиту і зубного каменю. Використовували стандартні лабораторні методи для визначення морфологічних показників крові – кількості еритроцитів, лейкоцитів і тромбоцитів, а також біохімічних – вмісту гемоглобіну, глюкози, креатиніну, сечовини, активності амінотрансфераз, гамма-глутамілтранспептидази і лужної фосфатази тощо. Крім того, задіяний рентгенографічний метод для діагностики стану органів ротової порожнини в хворих собак. На основі отриманих даних встановлено, що хвороби ротової порожнини у цих тварин супроводжуються істотними змінами окремих морфологічних і біохімічних показників крові, що може свідчити про системну реакцію організму на патологічний процес. Зокрема, відмічали лейкоцитоз (за стоматиту і пародонтиту), гіпохромемію (за зубного каменю), зниження величини гематокриту (за пародонтиту), тромбоцитопенію

(за всіх патологій), а також підвищення в її плазмі активності аспартатамінотрансферази (за стоматиту і пародонтиту), зниження активності лужної фосфатази (за стоматиту), зниження активності гамма-глутамілтранспептидази (за зубного каменю) та підвищення (за пародонтиту), гіперглікемію і гіперазотемію (за стоматиту і пародонтиту). Встановлені зміни гематологічних показників є відображенням розвитку патологічного процесу в ротовій порожнині собак та можуть відігравати ключову роль у діагностиці і прогнозуванні перебігу цих захворювань, виборі оптимальної стратегії лікування та моніторингу його ефективності

Ключові слова: пародонтит; зубний камінь; стоматит; гінгівіт; епуліс; морфологічні та біохімічні дослідження