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Adenovirus infections in dogs: Diagnostic features

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Abstract. In the general pathology of dogs, viral diseases occupy a leading place, and infectious hepatitis, the causative agent of which is a virus of the *Adenoviridae* family, is of particular concern. Recently, the virus has spread to many countries around the world, which indicates changes in the properties of the pathogen. At the same time, the epizootic situation concerning infectious diseases, including adenoviruses, whose development is influenced by the mass keeping of dogs, has worsened in Ukraine. The purpose of this study is to supplement, clarify, and generalize data on epizootological features, morphological and biochemical parameters of blood and pathological and anatomical changes in type I canine adenovirus. The following research methods were used to conduct the research: epizootological analysis, clinical (determination of the general clinical condition of animals), pathological and anatomical (detection of macroscopic changes), haematological (morphological and biochemical parameters of blood) and statistical (processing of digital data to determine the probability of changes in indicators). According to the results of comprehensive studies, it was proved that dogs of different breeds, including mongrels, are susceptible to type I adenovirus, and the peak manifestation of the disease is the spring-summer period in animals aged one to two years. Infectious hepatitis is characterized by the development of erythrocytopenia, a decrease in haematocrit, leucocytosis, and lymphocytopenia. Changes in biochemical indicators are characterized by a decrease in haemoglobin, creatinine, urea, glucose in the blood, and a decrease in the activity of α -amylase and an increase in the content of total bilirubin, hyperfermentaemia of alkaline phosphatase and alanine aminotransferase. The most pronounced pathoanatomical changes are an increase in the size of the liver with the development of necrosis, and in the gastrointestinal tract-haemorrhages in the small intestine. The multisystem pathogenic effect of the virus is characterized by nephrosis, pinpoint haemorrhages in the pancreas, and inflammatory changes have been established in the lymph nodes. As a result of an experimental study of haematological parameters and pathoanatomical changes, a complex pathogenesis of the disease with multiple organ failure was established. In the study of infectious diseases of dogs, the most important aspect is clinical and diagnostic information content. Therefore, scientific research on a more profound understanding of the diagnosis of canine adenovirus will determine the algorithm for justifying the diagnosis

Keywords: infectious hepatitis, epizootological features, morphological and biochemical indicators of blood, erythrocytopenia, macroscopic changes

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Introduction

Since ancient times, man needed an assistant in the household and hunting, and the most suitable animal for this was a dog that was tamed over ten thousand years ago. Today, dogs are one of the most popular animal species and companions for humans, as evidenced by the increase in their number by 1.4% over the past decade (Ghasemzadeh & Namazi, 2015). It is established that more than 60% of European families have pets, most of which are dogs. Numerous studies have confirmed the significant and irreplaceable role of pets in human life and their positive impact on the psychosocial and mental health of their owners. Owning a pet can increase the activity of owners, reduce the risk of depression and mental stress, and increase self-esteem (Katagiri & Oliveira-Sequeira, 2008; Ghasemzadeh & Namazi, 2015). Therefore, an increase in the population of small animals, including dogs, has recently been recorded, which inevitably leads to an exacerbation of the epizootic situation (Netherton & Wileman, 2011; Radzykhovskiy, 2016). Usually, diseases of infectious aetiology in dogs, in contrast to productive animals, do not lead to economic losses because hobby-class animals have a moral and psychological significance for their owners, and the death of a pet as a result of the disease can provoke a stressful state in them.

Many problems with the functioning of the gastrointestinal tract seem similar, but in reality, there are many aetiological factors that can lead to the death of an animal. Considering the data of professional literary sources, the authors of the present study state that in dogs, the main causes of the development of diarrhoea followed by symptoms of haemorrhagic enteritis are usually viruses, bacteria, and parasites (Rocha-Gizzi et al., 2014; Ortega et al., 2017; Lisova & Radsikhovskiy, 2018). On the territory of Ukraine, 60% of dogs are inpatient diagnosed with diseases with damage to the digestive system (Lisova & Radsikhovskiy, 2018). The most common are viral enteritis, hepatitis, and gastroenteritis of unknown aetiology.

World literature sources indicate that the main causative agents of adenovirus infection in dogs are of two types: canine adenovirus type I (Rubart's disease, CAV-1), which causes canine infectious hepatitis, and canine adenovirus type 2 (CAV-2), which is associated with respiratory type canine adenovirus. Types CAV-1 and CAV-2, which pertain to the *Adenoviridae* family, are closely related antigenically and genetically. Despite their antigenic and genetic affinity, they exhibit different patterns of cellular tropism. CAV-1 recognizes vascular endothelial cells and liver and kidney parenchymal cells as targets for viral replication, and CAV-2 efficiently replicates in the respiratory tract and, to a limited extent, in the intestinal epithelium (Decaro et al., 2008; Balboni et al., 2019; Zhu et al., 2022). One of the most frequent causes of gastrointestinal disorders in dogs is an infectious factor, which accounts for 63%, and aetiologically, these are viruses of the *Adenoviridae* and *Parvoviridae* families and bacteria of the *Salmonella* genus. It is worth separately noting the significant prevalence and, accordingly, the aetiological factor of the parasitic agent, namely *Giardia*, which was found in 37% of dogs with the corresponding symptoms. Of particular concern is the presence of mixed infection, i.e., the presence of two or more pathogens of different nosological groups in the body (Radzykhovskiy, 2016; Mitchell et al., 2017; Dowgier et al., 2018).

Adenoviruses affect the respiratory tract, gastrointestinal tract, and excretory system of animals. As a rule, they cause subclinical infection, but avian and canine adenoviruses cause a clinical manifestation of the disease. In animals with reduced immunity, the infection causes high morbidity and mortality. Adenovirus was first isolated in 1953 from culture explants of degenerated human adenoids by Wallace Rowe and his colleagues. Canine adenovirus belongs to the family *Adenoviridae* and the genus *Mastadenovirus* and is divided into canine adenovirus serotypes (Decaro et al., 2008; Timurkan et al., 2018; Musto et al., 2021).

Adenovirus infection of the first type (CAV-1), infectious hepatitis, Rubart's disease is an acute contagious disease characterized by fever, catarrhal inflammation of the mucous membrane of the respiratory tract and intestines, liver, and central nervous system damage. The disease is common in many countries of the world and occurs both among domestic animals and in the wild. Regular vaccination has reduced the number of clinical cases of the disease. The CAV-1 virus affects a considerable group of carnivores, including dogs of various breeds and ages, but most often puppies aged 2 to 6 months get sick. Therewith, the mortality rate is 30-40% and in the literature it is noted that female virus carriers can infect their puppies and males for many years (García-Marín et al., 2018; Hornsey et al., 2019; Yang et al., 2019).

Adenovirus type 2 is a highly contagious virus that damages the respiratory tract in dogs, especially puppies, when kept in conditions of considerable crowding. CAV-2 provokes disorders in the respiratory organs, including tonsillitis, pharyngitis, tracheitis, bronchitis, and having an affinity for the epithelium of the upper respiratory tract. This virus was first detected in Canadian shelter dogs in 1961 with symptoms of upper respiratory tract infection, and in the following years its presence was reported in many countries such as Italy, Brazil, and India (Hechinger et al., 2017; Ramidi et al., 2019; Bergmann et al., 2020).

Adenovirus infection in dogs is characterized by multifaceted clinical symptoms, but the main ones should be highlighted, namely lethargy, vomiting, dehydration, pallor, hypothermia, leukocytosis, neutrophilia, lymphopenia, and thrombocytopenia, increased activity of alkaline phosphatase, alanine aminotransferase, and creatine kinase. Over time, anaemia, hypoalbuminaemia, bilirubinaemia, bilirubinuria, haematuria, and proteinuria, splenomegaly, hepatomegaly, and pulmonary haemorrhage progress (Bulut et al., 2013; Pereira et al., 2021).

Based on the analysis of literature sources, the results of monitoring and own research, it was found out that viral diseases occupy a leading place in the infectious pathology of dogs and cause their mortality. And one of the most common is infectious hepatitis (Decaro et al., 2008; Radzykhovskiy, 2016; Mitchell et al., 2017). However, despite considerable progress in investigating the aetio-pathogenesis of infectious diseases of animals and optimizing preventive measures, timely diagnosis of adenovirus infection in dogs stays an urgent issue on which the therapeutic effect depends.

The purpose of this study was to establish the nosological profile of viral diseases in dogs and to determine the share of adenovirus infection, as well as to conduct an analysis of morphological and biochemical indicators

of blood, the state of erythropoiesis and pathomorphological changes to establish added diagnostic markers of this disease.

Materials and Methods

The study was conducted during 2021 at the Faculty of Veterinary Medicine at the National University of Life and Natural Sciences of Ukraine, as well as at the base of the veterinary clinics “Bahira” (Zhytomyr) and “Viktoria” (Kyiv). The study material was pedigreed and mongrel dogs with adenovirus infection.

During the study, the main rules of good laboratory practice (GLP) (On approval of the Procedure..., 2009), the provisions of the “General ethical principles of animal experiments” adopted by the First National Congress of Bioethics (Kyiv, 2001) were followed (On the protection..., 2021). The entire experimental part of the study was conducted per the requirements of the international principles of the “European Convention for the Protection of Vertebrate Animals Used for Experimental and Other Purposes” (Strasbourg, 1986) (European Convention..., 1986), “Rules for Conducting Work Using Experimental Animals”, approved by the Order of the Ministry of Healthcare No. 281 dated November 1, 2000 “On Measures to Further Improve Organizational Forms of Work with the Use of Experimental Animals” and the corresponding Law of Ukraine “On the Protection of Animals from Cruelty” (No. 3447-IV dated 02/21/2006, Kyiv) (Law of Ukraine..., 2006). Euthanasia was performed using drugs that ensure rapid, painless death, according to the “European Convention for the Protection of Vertebrate Animals Used for Experimental and Other Purposes” (European Convention..., 1986).

At the first stage of research, the epizootic situation regarding infectious diseases of dogs in the service area of veterinary medicine clinics was analysed. For this, the authors of this study used the primary documentation of outpatient logs of animal admissions. At the same time, the anamnestic data presented by the owners of dogs with a confirmed diagnosis or suspicion of adenovirus infection were additionally considered.

During the analysis of the documentation regarding the epizootological features of the course of the disease for the year 2021, the presence of viral pathogens was found and confirmed in 105 dogs, and adenovirus infection in 60 animals.

Diagnostic studies to confirm adenovirus were conducted using VetExpert express test systems (CAV Ag, solid phase immunochromatographic analysis for qualitative detection of *Canine Adenovirus* antigen) manufactured in Poland. Diagnostic studies on the presence of adenovirus antigen in dogs were also conducted at the private veterinary

laboratory Bald LLC (Kyiv) using enzyme-linked immunosorbent assay and polymerase chain reaction. Morphological and biochemical indicators of blood were studied using a BioChem SA (USA) biochemical analyser using High Technology, Inc. reagents (USA).

At the second stage of research, haematological studies were conducted and indicators of erythropoiesis in the blood of dogs ($n = 21$) with adenovirus infection were determined. The control group included clinically healthy dogs ($n = 10$).

General clinical blood analysis included the determination of the number of erythrocytes and leukocytes by the melanger method in a chamber with a Goryaev grid; haemoglobin content in blood – haemoglobin cyanide method; haematocrit value – by Shklyar microcentrifugation. Based on the obtained results, red blood indices were calculated – the haemoglobin content in one erythrocyte (MCH), the average concentration of haemoglobin in an erythrocyte (MCHC), and the average volume of erythrocytes (MCV).

During the biochemical examination of blood serum, the following were determined: the content of total protein – refractometrically, the concentration of urea – by colour reaction with diacetyl monooxime, and creatinine – by the Jaffe method, the activity of aspartate aminotransferase (AST) and alanine aminotransferase (ALT) by the Reitman-Frankel method. Blood for research was collected from dogs from the superficial vein of the forearm *v. Anterbrachium* and medial or subcutaneous vein of the lower leg *v. Saphena*.

To determine the replication and persistence of adenovirus, a pathoanatomical study of dogs of different ages who died from infectious hepatitis was conducted. Pathoanatomical autopsy of dog corpses was performed in the dorsal position, by partial evisceration in the generally accepted sequence. Each time, the autopsy was recorded, and the detected changes were photographed with a Nikon camera (Indonesia).

Digital data were biometrically processed according to generally accepted methods of variational statistics using the computer software Statistica 6.0 and Microsoft Excel 2007. The probability of differences between the values of indicators was evaluated according to the Student's t-test. Three degrees of probability were calculated: * $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$.

Results and Discussion

To find the epizootic situation regarding adenovirus infection and its prevalence, epizootic monitoring was conducted, and the level of morbidity of dogs with various viral diseases was analysed. Based on the results obtained, a nosological profile of viral diseases of dogs was formed (Fig. 1).

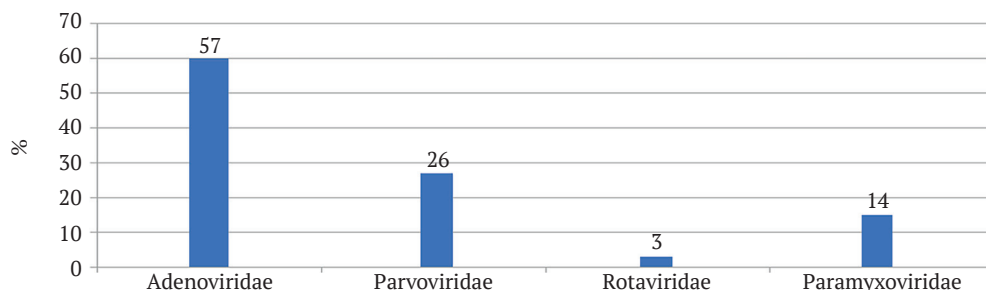


Figure 1. Nosological profile of viral diseases of dogs in 2021, %

In 2021, pathogens of viral infectious diseases were identified and confirmed in 105 dogs as follows: adenovirus – 57%, parvovirus – 26%, rotavirus – 3%, and paromyxovirus – 14% (Fig. 1). The obtained results coincide with the data of S. A Headley *et al.*, (2018), which note the tension of the epizootological situation regarding viral diseases of dogs and the rapid spread of infectious ones, with a growing trend not only in Ukraine, but also throughout the world. Therewith, a special place is occupied by adenovirus infection, which is described in Ukrainian and foreign scientific publications (Ortega *et al.*, 2017; Lisova & Radsikhovskiy, 2018; Ji *et al.*, 2020).

The initial diagnosis of infectious diseases begins with an epizootological analysis, which highlights the patterns of infectious disease development. During the study of epizootological features, certain factors were considered – the migration of animal owners with their animals to other clinics of veterinary medicine, as well as the pedigree, seasonality, and age-related susceptibility to viral diseases were determined by analysing the data of 44 dogs infected with adenovirus. Thus, the most susceptible to adenovirus infection of the first type are mongrel dogs – 12 (27%), and among pure-bred dogs: Dobermanns – 9 (20%), Boxers – 8 (18%), and Rottweilers – 5 (11%). Adenovirus was considerably less frequently diagnosed in German shepherds, Kurtzhaars, and Great Danes (5%) and the lowest number of cases (2%) was found in Shepherds (Asian and European), Spaniels and Dalmatians. Adenovirus infection manifests itself seasonally, specifically in the spring-summer period;

it accounts for 27 to 40% of cases, which corresponds to the pattern of the peak manifestation of viral diseases. During this period, there is close contact between animals during longer walks and exhibitions, which is facilitated by the climatic conditions of Ukraine.

One of the important criteria for assessing epizootological features is the determination of age-related predisposition to adenovirus infection. Therewith, the highest rate was diagnosed in dogs aged one to two years – 26%, in puppies and dogs aged up to one year, and from two to five – 21%, and in animals aged two to six months – 18%. Adult animals over the age of five are susceptible to this disease in 18%. In most infectious diseases, maternal (colostral) antibodies play a significant role, and adenovirus infection is no exception, which was not diagnosed in puppies under two months of age according to this study.

Two forms of manifestation of adenovirus infection were established – intestinal, which is characterized by damage to the gastrointestinal tract, and adenovirus of the first type acts as an antigen (Fig. 2 A, B), and specific – haemorrhagic diarrhoea, vomiting, jaundice and dehydration, sometimes ascites developed. In case of adenovirus of the second type, damage to the respiratory organs was established with the development of a corresponding symptom complex, the specific manifestation of which is the occurrence of keratitis, called “blue eye” (Fig. 2 C). Notably, eye damage and the manifestation of uveitis is observed in adenovirus type I. At the same time, Zhu *et al.*, 2022 indicate that CAV-1 and CAV-2 are closely related antigenically and genetically.



Figure 2. Main clinical symptoms in dogs with adenovirus

Note: A – haemorrhagic enteritis and lethargy due to CAV-1; B – jaundice of the visible mucous membrane of the eyes due to adenovirus CAV-1; C – uveitis due to CAV-1 and CAV-2

Analysing the results of the authors' earlier research and studies presented in specialized literature sources (Hornsey *et al.*, 2019; Thompson *et al.*, 2020; Musto *et al.*, 2021), it was established that the respiratory form of adenovirus infection has a benign course, the mortality rate does not exceed 10%, and it is effectively treated according to generally established protocols. But the intestinal form often leads to generalization of the pathological process and is characterized by a considerable mortality rate of 40%. Therefore, for a more detailed definition of

the specific features of the physiological state of animals under adenovirus type I, changes in the morphological composition of the blood were subject to investigation (Table 1). Blood parameters are sensitive and informative indicators of the state of the body, undergo changes due to the action of both exogenous and endogenous factors. During the experimental study, the manifestation of an intestinal form of adenovirus with characteristic symptoms of gastrointestinal tract damage was established in 21 out of 39 animals.

Table 1. Morphological parameters of the blood of dogs with adenovirus, M ± m

Indicator	Clinically healthy animals (control group), n = 10	Animals infected with adenovirus (experimental group), n = 21
Red blood cells (RBC), 10 ¹² /l	6.1 ± 0.4	4.3 ± 0.6*
Haematocrit value (HCT), %	45.4 ± 2.4	27.9 ± 1.7***
Platelets (PLT), 10 ⁹ /l	428.1 ± 11.2	343.6 ± 34.1*
White blood cells (WBC), 10 ⁹ /l	9.4 ± 0.2	19.2 ± 1.3***
Neutrophils (NEU), %	J	0
	S	58.5 ± 1.4
	B	1.7 ± 0.2
Eosinophils (EO), %	1.8 ± 0.3	1.2 ± 0.1
Monocytes (MON), %	3.0 ± 0.2	1.2 ± 0.3***
Lymphocytes (LYM), %	35.0 ± 1.3	18.6 ± 3.2***
ESR, mm/h	4.4 ± 0.5	17.0 ± 2.2***

Note: *P < 0.05; **P < 0.01; ***P < 0.001, significant compared to the control group

According to the results of the haematological studies (see Table 1), it was found that with adenovirus infection of the first type in the blood of dogs, the number of erythrocytes significantly decreases by 29% (P < 0.05) compared to animals of the control group. It is assumed that a decrease in the number of red blood cells in the blood of dogs infected with adenovirus stimulates the development of an infectious agent and causes their haemolysis. It was established that the haematocrit value is probably lower by 17.5% (P < 0.001) compared to that of healthy animals and, considering erythropenia, may indicate the development of anaemia. A probable decrease in the number of platelets in the blood by 20% (P < 0.05) is associated with their destruction in the liver and spleen due to the features of the pathogenic influence of adenovirus. A pathological increase in the number of leukocytes in the blood by 2 times (P < 0.001) occurs under an infectious agent, which stimulates the formation of leukocytes and is a protective reaction of the body. In adenovirus infection, neutrophilic leucocytosis was established as a result of a probable increase of 20% (P < 0.001) in the number of segmented neutrophils, which indicates a shift of the leukocyte formula to the right and characterizes

anaemia and the development of hepatorenal syndrome. In relation to the significant decrease in the number of monocytes by 2.5 times (P < 0.001), this fact may indicate not only the onset of anaemia, but also bone marrow damage. A probable decrease of 1.9 times (P < 0.001) in the number of lymphocytes was also established, which distinguishes infectious processes with an acute course. Lymphocytopenia was probably caused by low molecular weight proteins – interferons, which are synthesized in response to a viral infection. The rate of sedimentation of erythrocytes in the blood of infected animals probably increased by 4 times (P < 0.001) compared to a similar indicator in healthy animals. This fact is possibly related to an increase in plasma concentration of acute phase proteins, namely fibrinogen, C-reactive protein, and immunoglobulins (Table 1).

The results of biochemical studies of the blood serum of dogs with adenovirus infection type I did not differ significantly from similar indicators in clinically healthy animals (Table 2). Therewith, considering the “red blood” indices, they characterize the intensity of maturation of red blood cells and their saturation with haemoglobin in the bone marrow due to adenovirus hepatitis.

Table 2. Biochemical indicators of dog blood serum with adenovirus, M ± m

Indicator	Clinically healthy animals (control group) n = 10	Animals infected with adenovirus (experimental group), n = 21
Haemoglobin content in one red blood cell (MCH), pg	23.6 ± 1.6	22.3 ± 1.8
Average concentration of haemoglobin in erythrocytes (MCHC), g/dl	33.9 ± 1.4	33.5 ± 1.7
Average red blood cell volume (MCV), fl	67.1 ± 3.7	66.1 ± 2.8
Haemoglobin (HGB), h/l	145.0 ± 12.5	93.1 ± 7.2**
Glucose, mmol/l	4.2 ± 0.2	1.7 ± 0.4***
Total bilirubin, µmol/l	0.22 ± 0.2	2.8 ± 0.3***
Alkaline phosphatase (ALP), IU/l	34.6 ± 2.7	74.8 ± 3.4***
Total protein, g/l	71.0 ± 1.8	69.6 ± 8.4
Aspartate aminotransferase (AST), IU/l	50.1 ± 3.8	46.7 ± 4.1
Alanine aminotransferase (ALT), IU/l	46.6 ± 3.3	113.8 ± 6.4***
De Ritis coefficient, IU/l	1.24 ± 0.2	0.42 ± 0.3**
Urea, mmol/l	5.3 ± 0.2	2.2 ± 0.4***
Creatinine, µmol/l	97.0 ± 3.9	48.8 ± 7.2***
(α-Amylase), IU/L	1120.0 ± 65.4	205.0 ± 15.2***

Note: *P < 0.05; **P < 0.01; ***P < 0.001, significant compared to the control group

Notably, according to the indicators presented in the Table 2, it is possible to state the development of microcytic hypochromic iron deficiency anaemia. Furthermore, this is confirmed by a significant decrease in haemoglobin content by 36% ($P < 0.01$) compared to the control. Adenovirus infection was diagnosed as a violation of the functional state of the liver, as evidenced by changes in such biochemical indicators as a probable decrease in urea concentration by 2.4 times ($P < 0.01$), the De Ritis coefficient by 2.95 times, and an increase in the level of total bilirubin by 12.7 times ($P < 0.001$). At the same time, there is a 2.4-fold increase in ALT activity in the blood serum ($P < 0.001$), which characterizes the development of cytolysis of liver cells. A probable increase in the activity of alkaline phosphatase by 2.2 times ($P < 0.001$) with a simultaneous decrease in the activity of α -amylase by 5.5 times ($P < 0.001$) was also established, which characterizes the development of hepatopathology in infected dogs.

Creatinine concentration is an important indicator of kidney activity, especially their filtration capacity. During adenovirus infection, this indicator was characterized by probably 2 times lower values ($P < 0.001$) than in healthy animals, which also indicates changes in muscle mass due to exhaustion of the body.

When diagnosing adenovirus in dogs, the concentration of glucose in the blood serum should be analysed because this carbohydrate is a vital energy substrate, which in infectious hepatitis acquires values significantly lower by 2.5 times ($P < 0.001$) than in healthy animals. The authors of the present study believe that this fact characterizes hypoglycaemia due to the occurrence of hepatorenal syndrome and damage to the gastrointestinal tract. In animals with low blood glucose levels, there is a compensatory increase in gluconeogenesis, which is primarily inherent in the liver, as well as to some extent the cortical layer of the kidneys and the epithelium of the small intestine (Table 2).

Thus, the results of the analysis of morphological and biochemical parameters of dog blood indicate a multisystem effect of adenovirus infection of the first type on their body. The obtained results, namely anaemia and an increase in the activity of liver enzymes in the blood serum and changes in indicators characterizing the damage to the renal system, coincide with the data of other scientists (Verin *et al.*, 2019; Polovitzer *et al.*, 2022).

For a comprehensive study of the deceased animal, it is necessary to conduct an autopsy with clarification of the correctness of the lifetime diagnosis. Therewith, the cause of death of animals can be determined by pathological and morphological changes in the organs. Organ damage caused by adenovirus infection of the first type depends on the duration and severity of the disease. Usually, the corpses of puppies that have died from an adenovirus infection are depleted and anaemic. Their serous integuments are dry. During an autopsy, a considerable amount of clear or serous-haemorrhagic fluid was found in the abdominal cavity of dog corpses. Haemorrhages and catarrhal inflammation of the duodenum were observed on the mucous membrane of the small intestine, and haemorrhagic foci were observed in the thymus and pancreas. The lymph nodes were enlarged, hyperaemic, and swollen. The spleen was enlarged, dense, and fibrinous perisplenitis (inflammation of the connective tissue capsule covering the spleen) with central pyogranulomatous necrotic inflammation (splenitis) was observed, sometimes haemorrhages and infarctions were found on the surface (Fig. 3).

In isolated cases, the mucosa of the small intestine was light pink, without damage or necrosis. The surface of the villi epithelium is destroyed. The contents of the intestines are liquid, the faecal masses had an unpleasant smell, their colour ranges from dirty yellow to dark red (Fig. 4).

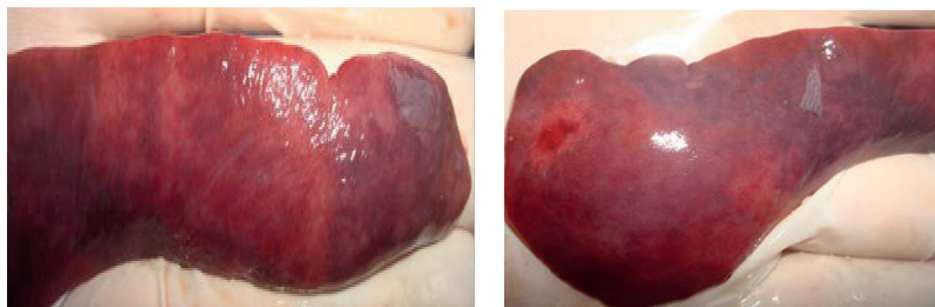


Figure 3. Macroscopic changes in the spleen of a dog with adenovirus type I

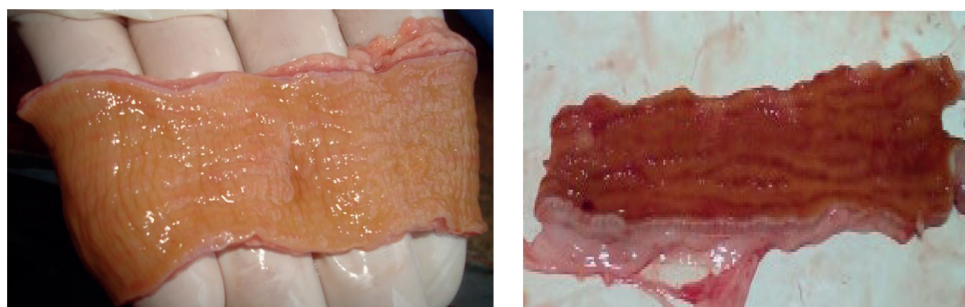


Figure 4. External view of a section of a fragment of the small intestine of a dog with adenovirus type I

The faeces contained mucus. Haemorrhagic enteritis has been established in most animals due to adenovirus infection. Macroscopic changes of the liver in adenovirus infection type I are considered pathognomonic, namely an increase in size (hepatomegaly), a yellowish-brown colour, full blood with isolated haemorrhages and rounded areas of necrosis, a loose consistency, which collapses under slight pressure. The gallbladder is grey green, swollen, and thickened,

pear-shaped, without damage, filled with bile inside, which to some extent coincides with the results of research by M. Wong *et al.* (2017) (Fig. 5).

During the development of light pink lung disease, heterogeneous areas of consolidation due to bronchopneumonia are noticeable. The consistency of the organ is doughy, loose to the touch and with the phenomena of pneumonia, atelectasis of the lungs is noted (Fig. 6).



Figure 5. Macroscopic changes in the liver and gallbladder of a dog with adenovirus type I



Figure 6. Macroscopic view of the dog's lungs with adenovirus type I

Kidneys are smooth, single papilla, have a bean-like shape, grey-red colour, flabby consistency (Fig. 7 A). The capsule is easily removed. On the section (Fig. 7 B), depending on the duration of the disease, the pattern is from weakly expressed to indistinct, the edges of the section do

not converge. Some animals were diagnosed with capsule haemorrhages and nephrotic changes.

Preyß-Jägeler *et al.* (2022) note that infectious agents can cause glomerulopathy and acute kidney injury and are a common complication and a common cause of death in dogs.

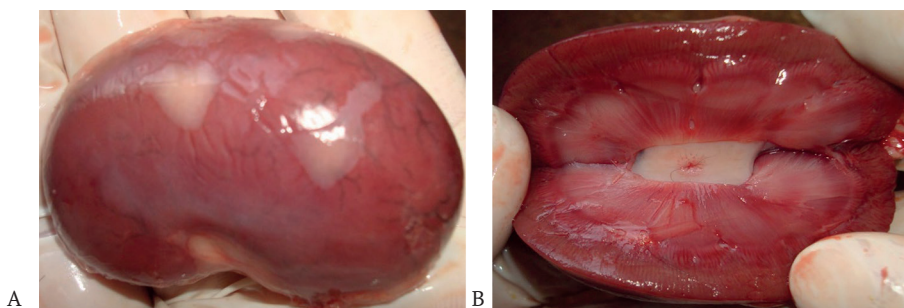


Figure 7. Macroscopic view of the dog's kidneys with adenovirus type I

In case of adenovirus infection type I in dogs, the pancreas is slightly enlarged, hyperaemic and blood-filled with pinpoint haemorrhages.

Pathological and anatomical changes were also found in the lymph nodes, namely serous lymphadenitis with individual or multiple point haemorrhages both from the surface and on the incision. Therewith, the colour of the lymph nodes ranges from greyish red to dark cherry.

Conclusions

This paper summarizes the authors' own and international experience concerning the main aspects of epizootological features, clinical manifestation and pathological and morphological changes upon canine adenovirus infection type I. It was established that among viral diseases, adenovirus antigen was diagnosed in 57% of dogs under study, with specific clinical symptoms of damage to respiratory organs

and disorders of the gastrointestinal tract. Epizootologically, adenovirus type I is characterized by spring-summer seasonality with a frequency of occurrence in dogs from 27% to 40%, and the most pronounced breed predisposition in Dobermanns, Boxers, and Rottweilers aged from one to two years (21%). One of the specific clinical symptoms of infectious hepatitis B in dogs is disorders in the gastrointestinal tract and liver, which are manifested by haemorrhagic diarrhoea and jaundice. A supplementary and specific marker of the clinical manifestation of adenovirus is eye pigmentation, the so-called “blue eye”.

The development of microcytic hypochromic iron deficiency anaemia was established based on the results of a decrease in the number of red blood cells in the blood by 29%, haematocrit value – by 17.5% and haemoglobin

content – by 35-40%. Therewith, a significant increase in the total bilirubin content in blood serum should be noted – by 12.7 times, alkaline phosphatase activity – by 2.2 times, and ALT – by 2.4 times, and a decrease in urea concentration – by 2.4 times, which indicates the development of hepatitis. This is confirmed during an autopsy and is a pathognomonic symptom. A 2-fold decrease in creatinine concentration indicates a reaction of the renal system and considering neutrophilic leucocytosis with a shift in the leukocyte formula to the right, the development of hepatorenal syndrome. A 2.5-fold decrease in the concentration of glucose in the blood serum was also found, which indicates the development of hypoglycaemia, inherent in diseases of the gastrointestinal tract with the manifestation of haemorrhagic enteritis.

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Аденовірусні інфекції у собак: особливості діагностики

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Анотація. У загальній патології собак вірусні хвороби посідають провідне місце, а особливе занепокоєння викликає інфекційний гепатит, збудником якого є вірус родини *Adenoviridae*. За останні роки вірус поширився в багатьох країнах світу, що свідчить про зміни властивостей збудника. Водночас і в Україні загострилася епізоотична ситуація щодо інфекційних хвороб, включаючи аденовірусні, на розвиток яких впливає масове утримання собак. Метою роботи є доповнення, уточнення та узагальнення даних щодо епізоотологічних особливостей, морфологічних і біохімічних показників крові та патологоанатомічних змін за аденовірозу собак першого типу. Для проведення досліджень були використані такі методи досліджень як: епізоотологічні (епізоотологічний аналіз), клінічні (визначення загального клінічного стану тварин), патологоанатомічні (виявлення макроскопічних змін), гематологічні (морфологічні та біохімічні показники крові) та статистичні (обробка цифрових даних з метою визначення вірогідності змін показників). За результатами проведених комплексних досліджень доведено, що до аденовірозу першого типу сприйнятливі собаки різних порід, включаючи безпородних, а пік маніфестації хвороби – це весняно-літній період у тварин від одного до двох років. Для інфекційного гепатиту характерним є розвиток еритроцитопенії, зниження гематокритної величини, лейкоцитоз та лімфоцитопенія. Зміни біохімічних показників характеризуються зменшенням у крові вмісту гемоглобіну, креатиніну, сечовини, глюкози і зниженням активності α -амілази та збільшенням вмісту загального білірубіну, гіперферментемією лужної фосфатази та аланінамінотрансферази. Найвираженішими патологоанатомічними змінами є збільшення розмірів печінки з розвитком некрозу, а у шлунково-кишковому тракті – крововиливи в тонкому відділі кишечника. Мультисистемний патогенний вплив вірусу характеризується нефрозом, точковими крововиливами у підшлунковій залозі, а у лімфатичних вузлах встановлено зміни запального характеру. В результаті експериментального дослідження гематологічних показників та патологоанатомічних змін встановлено складний патогенез хвороби з поліорганною недостатністю. У вивченні інфекційних хвороб собак найважливішою є клініко-діагностична інформативність. Тому, наукові пошуки щодо глибшого розуміння діагностики аденовірозу собак визначають алгоритм обґрунтування постановки діагнозу

Ключові слова: інфекційний гепатит, епізоотологічні особливості, морфологічні та біохімічні показники крові, еритроцитопенія, макроскопічні зміни