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DOXYCYCLINE INTAKE AND DISTRIBUTION IN THE BODY OF BROILER CHICKENS WITH ORNITHOBACTERIOSIS

A. M. TYSHKIVSKA, *Graduate Student, Department of Pharmacology, Parasitology and Tropical Veterinary Medicine*
http://orcid.org/0000-0003-4419-2174
National University of Life and Environmental Sciences of Ukraine, Kyiv, Ukraine
E-mail: annatyshkivska@gmail.com
V. B. DUKHNYTSKYI, *Doctor of Veterinary Sciences, Professor, Department of Pharmacology, Parasitology and Tropical Veterinary Medicine*
http://orcid.org/0000-0002-9670-1244
E-mail: dukhnytskyjvb@ukr.net
National University of Life and Environmental Sciences of Ukraine, Kyiv, Ukraine
M. YU. TYSHKIVSKYI, *Candidate of Veterinary Sciences, Associate Professor,*
http://orcid.org/0000-0003-0826-5276
E-mail: tyshkivsky@ukr.net
Bila Tserkva National Agrarian University, Bila Tserkva, Ukraine
N. V. TYSHKIVSKA, *Candidate of Veterinary Sciences, Associate Professor*
http://orcid.org/0000-0003-4937-1390
E-mail: natalya.tyshkivska@gmail.com
Bila Tserkva National Agrarian University, Bila Tserkva, Ukraine

Abstract. *The clinical efficiency of the antibiotic is determined by its distribution in organs and tissues, the ability to penetrate the physiological and pathological barriers of the body. The article presents the results from a study of the intake, distribution, and excretion of doxycycline hyclate – the active substance of the antibiotic pollodoxin from the body of broiler chickens (the Cobb-500 cross) with ornithobacteriosis.*

It has been established that 24 hours after the pollodoxin solution application in broiler chickens with ornithobacteriosis, the highest content of its active substance (doxycycline hyclate) was found in the lungs, liver, slightly less – in the kidneys, and least – in the heart and pectoral muscles. After 48 and 72 hours, the content of doxycycline hyclate increases in the liver, kidneys, heart, and pectoral muscles compared to 24 hours, while in the lungs decreases slightly after 48 hours and does not differ from it after 72 hours. At 96 hours, the content of doxycycline hyclate in the kidneys, lungs, and pectoral muscles reaches maximum values; in the liver it is smaller than the previous one (72 hours), while in the heart it does not differ from it. Doxycycline hyclate does not show cumulative properties and "organ affiliation" during 96 hours of entry into the body of broiler chickens with ornithobacteriosis. After 24 hours of discontinuation of pollodoxin use (120 hours of the experiment), the content of doxycycline hyclate

in all studied organs decreases but remains high enough, indicating a relatively long elimination half-life and antimicrobial action. Pharmacokinetic indicators will allow the doctor to determine an effective drug that will provide a therapeutic effect and will prevent the development of resistance of microorganisms.

Keywords: *pollodoxin, doxycycline hyclate, broiler chickens, ornithobacteriosis, Ornithobacterium rhinotracheale, pharmacokinetic parameters*

Introduction

In conditions of intensive poultry farming, bacterial diseases with predominant respiratory system injury cause great economic damage. In recent years, in poultry farms, previously little-known diseases of various bird species have become widespread in Ukraine. Among them, ornithobacteriosis occupies an important place. The disease is characterized by respiratory system lesions, decreased growth, and increased mortality rates.

Considering that ornithobacteriosis causative agent (*Ornithobacterium rhinotracheale*) affects, foremost, the respiratory organs – lungs, trachea, air sacs, and the disease is often complicated by other microorganisms (mycoplasmas), or a secondary disease, therefore, pluripotential antibiotics are preferred in the treatment.

One of the main indicators that determine the antibiotic effectiveness in the body is its high bioavailability, the ability to penetrate and accumulate in high concentrations in the places of the pathological process, to have an elimination half-life sufficient for the antimicrobial effects (Fairchild et al., 2005; Sanders et al., 2016).

Several factors, among which the most important are the drug's chemical structure, the administration route, the frequency and duration of use, the animal's age, and the pathology presence (Ambrose et al., 2007; Barbosa et al., 2020), affect the drugs' bioavailability and distribution in the body.

Therefore, it is currently topical to study individual pharmacokinetic parameters of chemotherapeutic agents in the body of broiler chickens with ornithobacteriosis in order to find the most effective one.

Analysis of recent researches and publications

Ornithobacteriosis is a respiratory system disease in poultry, which is widespread in the world and causes significant economic damage. In broiler chickens, ornithobacteriosis leads to stunting and significant growth retardation, air sacculitis, pneumonia, and death. The disease develops as an independent nosological unit. It can also complicate the course of other bacterial and viral diseases (Ellakany et al., 2019).

Viruses cause integrity disruption of the respiratory system's mucous membrane, and so open the way for bacteria. The main pathogens of the respiratory system's pathology are *O. rhinotracheale* and mycoplasma. The ornithobacteriosis causative agent widespread occurrence is evidenced by the monitoring results of industrial poultry in Germany. During this monitoring, it was found that about 90% of the investigated birds had antibodies to the ornithobacteriosis causative agent (Szabó et al., 2017).

The ornithobacteriosis causative agent (*O. rhinotracheale*) is a small, gram-negative bacillus with rounded ends, does not form spores and capsules. It is extremely difficult to isolate it by classical bacteriological methods, and therefore, ornithobacteriosis often remains an "undiagnosed" and "undertreated" infection.

The circulating strains' wide population (449 strains and 9 serovars), the rapid development of resistance, and the *O. rhinotracheale* ability to acquire cross-species resistance due to plasmid conjugation significantly complicates the treatment of birds with ornithobacteriosis (Oca-Jimenez et al., 2017).

In vitro, several antibiotics are effective against *O. rhinotracheale* but, in practice, the results are ambiguous. The reason for this is precisely that the ornithobacteriosis causative agent is "accompanied" by other pathogens and a large number of *O. rhinotracheale* serotypes, the sensitivity of which to chemotherapeutic agents is rapidly changing.

O. rhinotracheale are most sensitive to tetracyclines, macrolides, fluorfenicol, semi-synthetic penicillins. In the European countries and Ukraine, it is recommended to control ornithobacteriosis by using antibiotics of the tetracycline and macrolide group (Mayahi et al., 2016).

Tetracyclines belong to broad-spectrum antibiotics and have high biological activity. Tetracycline's positive characteristics are resistance to digestive enzymes and gastric juice, the ability to be rapidly absorbed from the digestive tract, which is important for oral administration (Smith & Leyden, 2005; Ochsendorf, 2010; Bailey et al., 2016).

The pharmacokinetics of tetracyclines begins with the substance absorption in the initial part of the small bowel, and the effective concentration in the blood is reached in 2–4 hours. However, oral bioavailability varies significantly between drugs. In particular, doxycycline is better absorbed after internal administration, while chlortetracycline is almost not absorbed (Agwuh & MacGowan, 2005).

One of the most common tetracycline antibiotics used in veterinary medicine is doxycycline. It is a semi-synthetic antibiotic with a bacteriostatic effect. It has a wide spectrum of action against gram-negative and gram-positive aerobic and anaerobic bacteria, rickettsia, chlamydia, mycoplasma, and some protozoa (Roberts & Chopra, 2001; Mileva & Milanova, 2020).

Compared to other tetracyclines, the doxycycline's pharmacokinetic properties include better lipid solubility and tissue distribution, complete absorption, and a long half-life (Ho et al., 2014; Papich et al., 2016). The doxycycline's antimicrobial activity *in vitro* is more effective than in other tetracyclines, therefore, its best activity for the treatment of patients with respiratory pathology is noted (Bousquet et al., 1997; Widyasari-Mehta et al., 2016).

The drug's distribution and accumulation in the organs are important indicators that determine the antibiotic's activity at the site of the pathogen. The study of the doxycycline accumulation in the broiler chickens' organs shows that with the doxycycline introduction at a dose of 20 mg/kg b.w., on the 5th day of use the antibiotic in the highest concentration was found in the kidneys and liver, then in the lungs, and the lowest in the muscles (Anadón, et al., 1994). In other studies, 5 days after feeding 35-day-old broiler chickens with doxycycline at a dose of 10 mg/kg b.w., the highest drug concentrations were found in the kidneys, which was 6.5 μg/g, in the liver – 4.79 μg/g, in the muscles – 1.46 μg/g, in

the skin – 1.23 μg/g. The drug was completely excreted from the muscles after 6 days, from the liver and kidneys – 8, from the skin – 7 days (Mestorino et al., 2018). Similar results were also obtained by other researchers, finding the highest drug concentrations in the kidneys and liver (Kramer et al., 1978; Croubels et al., 1998; Gajda et al., 2014).

Purpose – to investigate the distribution of doxycycline hyclate when it is used in the form of the drug pollodoxin in the body of broiler chickens with ornithobacteriosis.

Materials and methods of research

All stages of research were carried out in accordance with the "European Convention for the Protection of Vertebrate Animals used for Research and Other Scientific Purposes" (Strasbourg, 1986) and approved by the Commission on Bioethics. The laboratory analysis was carried out in 2019–2020 on the basis of the chemical analytical sector of the Expert Center for Diagnostics and Laboratory Support "Biolights" (urban-type settlement Baryshivka), accredited in accordance with the requirements of DSTU ISO/IEC 17025:2017 according to № 201864, and on the basis of the laboratory of the pharmacology of the Department of Pharmacology, Parasitology and Tropical Veterinary Medicine, the National University of Life and Environmental Sciences of Ukraine (Kyiv). Statistic for analysis of experimental data was carried out by conventional methods of variation statistics and using the computer program Microsoft Excel 2019. The research was carried out on the basis of a poultry farm in Ivano-Frankivsk region. For the research, 20 broiler chickens of the Cobb-500 cross at the age of 25 days, with an average body weight of 1200 g, were used. By means of bacteriological examination, ornithobacteriosis was diagnosed in broiler chickens, which in some of them was complicated by colibacillosis.

Bacteriological research. To identify the causative agents of pneumonia and aerosaculitis, from a bird slaughtered in a state of light ether anesthesia, swabs were taken from the tracheal mucosa using a sterile SWAB applicator of the Biomerieux trademark. Selected material from the tracheal mucosa was plated by direct inoculation on blood agar. The cultivation was carried out under microaerophilic conditions at 37° C for 48 hours. The growth of small matte gray colonies was found after cultivation.

Maldi-Tof Mass Spectrometry. The two-day culture was identified by the method of Maldi-Tof mass spectrometry by direct deposition. The basic solvent was prepared from 475 μl of ultrapure deionized water, 500 μl of acetonitrile and 25 μl of 100% trifluoroacetic acid. To prepare the matrix, 250 μl of stock solution was added to a test tube with α-cyano-4-hydroxy-brown acid (HCCA). The mixture was vortexed thoroughly for 5 min until completely dissolved. To control the compliance and intensity of the peaks, the instrument was calibrated with the 100% concentration Bruker bacterial test standard (cat. № 255343). A small amount of bacterial culture was applied in a thin layer to the surface of the target strip. After drying, the dot was covered with 1 μl of the HCCA matrix solution, and an hour after its complete drying, the detection was performed. Mass spectra were obtained using Maldi-Tof in the mass range of m/z from 3000 to 20,000. The SCiLS Lab software was used to collect spectra, identify peaks, and analyze them. All settings and manufactur-

er's recommendations for standard use were employed.

For research, we used the drug pollodoxin of the INVESA trademark (the active substance is doxycycline hyclate 100 mg/ml), which was mixed in an amount of 1 cm^3 with 1000 cm^3 of drinking water. The broiler chickens were watered with pollodoxin solution for 4 days instead of drinking water in accordance with the recommended scheme used in industrial poultry farming. For poultry feeding, we used full-feed compound feeds produced by "Plakhtyanskiy Kormy".

The doxycycline hyclate intake and distribution in the body of broiler chickens with ornithobacteriosis was determined 24, 48, 72, and 96 hours after the pollodoxin solution administration per os. To determine the doxycycline hyclate content in the internal organs, three chickens were slaughtered in a state of light ether anesthesia in 120 hours from the beginning of the experiment. Pathological material samples (pectoral muscles, heart, lungs, liver, and kidneys) were frozen. Doxycycline hyclate determination by liquid chromatography-mass spectrometry was performed after preliminary extraction with acetonitrile and subsequent purification of the samples. Extraction, concentration, and purification of the studied samples were carried out on columns for solid-phase extraction. Doxycycline hyclate was extracted from the column with the eluent. The identification was performed by the time of the content, and the quantitative determination was carried out by the external standards method, by the area of the peaks. A Waters LC/MS/MS liquid chromatograph with a Premier XE tandem quadrupole detector was used for detection. The research results were considered by the variation statistics methods.

Results of the research and their discussion

During the clinical examination of sick broiler chickens, a general depression, ruffled plumage, apathy, and refusal to feed were noted. In some individuals, nasal discharge and swelling of the nasal mucosa were observed.

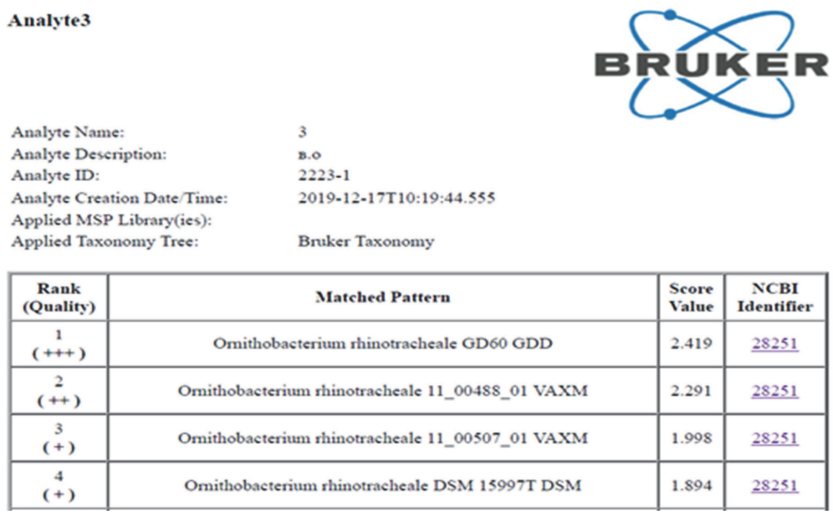
Bacteriological studies with the identification of Maldi-Tof mass spectrometry identified the isolated culture of microorganisms from the trachea as *O. rhinotracheale* (Fig. 1). The research results shown in Fig. 1 are original protocols that are automatically generated by the SCiLS Lab software.

After 24 hours from the beginning of the administration of the pollodoxin solution, its active substance (doxycycline hyclate) was distributed in descending order in the organs: lungs>liver>kidneys>heart>pectoral muscles (Table 1).

The distribution of doxycycline hyclate depended on the structure of the studied organs. Data in Table 1 show that after 24 hours, its content in the parenchymal organs (kidneys, liver, lungs) was 1.6–2.4 times higher than in the muscles and heart, the basis of the structure of which are striated muscles.

In 48 hours after the start of drinking the pollodoxin solution, the content of doxycycline hyclate increased compared to the previous value in the liver by 21%, kidneys – by 35%, heart – by 15%, pectoral muscles – by 10%. The content of doxycycline hyclate in the lungs during this experimental period decreased compared to the previous figure by 4%.

Drinking a pollodoxin solution during the third day was accompanied by a further increase in the content of doxycycline hyclate in the studied organs. Thus, at 72 hours, its content in the liver, kidneys, heart, and muscles was higher



Analyte3

BRUKER

Analyte Name: 3
Analyte Description: в.о
Analyte ID: 2223-1
Analyte Creation Date/Time: 2019-12-17T10:19:44.555
Applied MSP Library(ies):
Applied Taxonomy Tree: Bruker Taxonomy

Rank (Quality)	Matched Pattern	Score Value	NCBI Identifier
1 (+++)	Ornithobacterium rhinotracheale GD60 GDD	2.419	28251
2 (++)	Ornithobacterium rhinotracheale 11_00488_01 VAXM	2.291	28251
3 (+)	Ornithobacterium rhinotracheale 11_00507_01 VAXM	1.998	28251
4 (+)	Ornithobacterium rhinotracheale DSM 15997T DSM	1.894	28251

Fig. 1. Identification protocol of the studied cultures by mass spectrometry obtained using the SCiLS Lab software

by 24%, 44, 23, and 21%, respectively, than at 24 hours. The content of doxycycline hyclate in the lungs did not differ from that determined at 24 hours.

After 96 hours, the content of doxycycline hyclate in the kidneys, lungs, and muscles was higher in all previous study periods while in the liver it decreased to the level determined at 24 hours.

Data in Table 1 show that doxycycline hyclate in the body of broiler chickens with ornithobacteriosis is distributed in the largest quantities in the liver, kidneys, and lungs, and in much smaller – in the heart and muscles. Studies have not established an organ, in which doxycycline hyclate accumulates to maximum values in all periods of research, which indicates the absence of "organ affiliation" and material accumulation.

Higher levels of doxycycline hyclate in the liver, kidneys, and lungs than in the heart and muscles are explained by the better blood supply to these organs, as well as their participation in the processes of biotransformation and excretion from the body. Similar results on the distribution of doxycycline in broiler chickens have been obtained by foreign researchers, like us, but in studies conducted on healthy chickens.

1. The content of doxycycline hyclate in the organs of broiler chickens with ornithobacteriosis after feeding a solution of pollodoxin, μg/g (M ± m, n = 3)

Organ	Research time, hours				
	24	48	72	96	120
Muscle	2.11 ± 0.06	2.32 ± 0.11	2.56 ± 0.31	3.12 ± 0.04	1.09 ± 0.02
Kidney	4.27 ± 0.19	5.80 ± 0.08	6.15 ± 0.03	6.19 ± 0.02	2.49 ± 0.28
Liver	5.02 ± 0.05	6.09 ± 0.06	6.24 ± 0.08	5.04 ± 0.45	2.07 ± 0.03
Lung	5.09 ± 0.08	4.90 ± 0.10	5.06 ± 0.12	5.62 ± 0.23	1.61 ± 0.23
Heart	2.68 ± 0.44	3.09 ± 0.04	3.30 ± 0.20	3.28 ± 0.10	1.39 ± 0.21

After discontinuation of feeding a pollodoxin solution, the content of doxycycline hyclate in the internal organs decreases intensively, which indicates its biotransformation and excretion from the body (Table 1). Thus, 24 hours after discontinuation of pollodoxin (120 hours of the experiment) the content of doxycycline hyclate was lower than 96 hours: in the lungs – 3.4 times, pectoral muscles – 2.9 times, kidneys – 2.5 times, liver and heart – 2.4 times (Kramer et al., 1978; Anadón, et al., 1994; Croubels et al., 1998; Gajda et al., 2014; Widyasari-Mehta et al., 2016; Mestorino et al., 2018; Tyshkivska et al., 2020).

Although the content of the active substance (doxycycline hyclate) in the studied organs decreased rapidly 24 h after discontinuation of the pollodoxin solution, its relatively high levels indicate a long elimination half-life and antimicrobial action.

Conclusions and future perspectives

When feeding with pollodoxin solution broiler chickens with ornithobacteriosis, in accordance with the recommended scheme, the highest concentrations of its active substance (doxycycline hyclate) were found in the liver, kidneys, and lungs. Research has not established the cumulative properties and "organ affiliation" to doxycycline hyclate.

A day after the pollodoxin discontinuation in broiler chickens with ornithobacteriosis, doxycycline hyclate was distributed in the following sequence: pectoral muscles<heart<lungs<liver<kidneys. Directions for future research are to study the pharmacokinetic characteristics of antibiotics of other groups in the body of broiler chickens with ornithobacteriosis.

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Анотація. *Клінічна ефективність антибіотика визначається його розподілом в органах і тканинах, здатністю проникати через фізіологічні та патологічні бар›єри організму. У статті наведено результати досліджень надходження, розподілу та виведення доксицикліну гіклату – діючої речовини антибіотика польодоксину з організму курчат-бройлерів кросу КОББ-500 хворих на орнітобактеріоз.*

Встановлено, що через 24 год після застосування польодоксину хворим курчатам-бройлерам, найбільше доксицикліну гіклату міститься в легенях і печінці, дещо менше – в нирках, а найменше – у серці та грудних м'язах. Через 48 та 72 год вміст доксицикліну гіклату зростає у печінці, нирках, серці та грудних м'язах порівнюючи з показником на 24 год, тоді як у легенях незначно зменшується через 48 год та не відрізняється від нього через 72 год. На 96 год вміст доксицикліну гіклату у нирках, легенях та грудних м'язах набуває максимальних значень; у печінці він менший за попередній (на 72 год), тоді як у серці не відрізняється від нього. Доксицикліну гіклат не проявляє кумулятивних властивостей та «органної приналежності» впродовж 96 год надходження в організм хворих на орнітобактеріоз курчат-бройлерів. Через 24 год після припинення застосування польодоксину (на 120 год досліду), вміст доксицикліну гіклату в усіх досліджуваних органах зменшується, однак залишається достатньо високим, що засвідчує порівняно тривалий період його напіввиведення та протимікробну дію. Показники фармакокінетики дадуть змогу лікарю визначити ефективний препарат, який забезпечить терапевтичний ефект, і буде запобігати розвитку резистентності мікроорганізмів.

Ключові слова: *польодоксин, доксицикліну гіклат, курчата-бройлери, орнітобактеріоз, Ornithobacterium rhinotracheale, показники фармакокінетики*

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BIOCHEMICAL PARAMETERS OF BLOOD SERUM IN YOUNG PIGS UNDER FEEDING OF "LG-MAX" FEED ADDITIVE

S. A. TKACHUK, *Doctor of Veterinary Sciences, Professor, Department of Veterinary Hygiene named after Professor A. K. Skorokhodko*
https://orcid.org/0000-0002-6923-1793
National University of Life and Environmental Sciences of Ukraine, Kyiv, Ukraine
E-mail: ohdin@ukr.net
L. V. TKACHYK, *Graduate Student, Department of Veterinary Hygiene named after Professor A. K. Skorokhodko*
National University of Life and Environmental Sciences of Ukraine, Kyiv, Ukraine
E-mail: tkluz78@gmail.com
V. P. LYASOTA, *Doctor of Veterinary Sciences, Professor,*
Department of Veterinary and Sanitary Examination, Hygiene of Livestock Products and Pathological Anatomy named after Y. S. Zahaievskyi
https://orcid.org/ 0000-0002-2442-2174
Bila Tserkva, National Agrarian University, Bila Tserkva, Ukraine
E-mail: lyasota777@gmail.com

Abstract. *The acquired domestic and foreign experience of pig breeding development, an increase of animal productivity, and reduction of pork cost by 65–70% and more is determined by scientifically substantiated feeding. At the same time, the biochemical parameters of pig blood serum can be used to assess the functional state of the body and predict animal productivity and meat quality.*

The purpose of the study was to determine the morphological and biochemical blood parameters in young pigs with the inclusion of LG-Max and Sel-Plex feed additives to the main diet.

When using in pig feeding LG-MAX feed additive at a dose of 4.0 g/day, the blood biochemical parameters in pigs of the experimental groups compared with the control were within physiological limits according to the age of the animals.

At the same time, during the experimental period it was found that the biochemical parameters in blood serum of pigs of the experimental group compared to the control of the appropriate age are in the following dynamics: in 120-day-old pigs, significantly increases the content of total protein, the concentration of γ-globulins and aspartate aminotransferase, decreases the content of albumin, glucose, creatinine, cholesterol, and alkaline phosphatase; in 155-day-old pigs, the concentration of γ-globulins and the albumin/globulin ratio significantly increases and the urea, calcium, and chloride content increases; cholesterol and iron levels were significantly lower.

Keywords: *biochemical parameters, blood serum, LG-MAX feed additive*

Introduction

The organization of full-fledged animal feeding contributes to the achievement of an intensive type of pig breeding development and the formation of sufficient volumes of supply of high-quality and safe pig products. The acquired domestic and foreign experience in the development of pig breeding, increasing animal productivity, and reducing the cost of pork by 65–70% or more is determined by scientifically substantiated feeding (Ibatullin, 2017).

Today, it remains important to create conditions for improving the consumption and efficiency of feed use, obtaining quality food, which can be ensured by a high level of balanced feeding with the use of various feed additives. At this stage of feed industry development, a large number of feed additives are used in animal feeding (Polishchuk et al., 2010).

Among the variety of feed additives are those that contain polyunsaturated fatty acids (PUFAs). It is known that PUFAs play an important role in the functioning of a living organism, in particular humans. Currently, there are several classes of fatty acids that are part of dietary fats: saturated (myristic, palmitic, stearic, and others), monounsaturated (omega-oleic), polyunsaturated (omega-arachidonic, linoleic, omega 3-eicosapentaenoic, and docosahexaenoic). Indispensable (essential) Omega-6 and Omega-3 PUFAs are almost not synthesized in the human body but are received with food. For normal human life, Omega-3 PUFAs should be received not only in sufficient quantities but also in a balanced ratio with Omega-6 PUFAs (ideal Omega-6/3 ratio – 4:1) (Sirenko et al., 2012). It is metabolites that determine the physiological effects of PUFAs in the human body. By consuming in sufficient quantities, Omega-3 PUFAs replace Omega-6 in membrane phospholipids and numerous metabolic reactions. Eicosanoids formed from Omega-6 and Omega-3 PUFAs have opposite properties.

However, peroxidation of PUFAs into low-density lipoproteins plays an important role in the pathogenesis of atherogenesis (Jenkins et al., 2006). Intermediate metabolites of biohydrogenation of linoleic and linolenic acids are biologically active compounds that have a regulatory effect, prevent the occurrence of cancer and cardiovascular disease in humans (Kilian et al., 2009).

Analysis of recent researches and publications

It is known that the biochemical composition of blood can serve as an indicator of the functional state of the body and be used to predict animal productivity and meat quality. The circulatory system provides two important mechanisms of natural resistance: cellular and nonspecific humoral protection. The state of humoral mechanisms of natural resistance is evidenced by the following blood parameters: red blood cell count, hemoglobin concentration, white blood cell count, leukocyte blood formula, the concentration of total protein and its fractions (including albumins, α-, β- and γ-globulins). The morphological and biochemical blood composition has a significant impact on the intensity of metabolic and redox processes in pigs, and which might indicate the intensity of metabolism that, in turn, affects the level of their productivity. Metabolism is influenced by genotype, gender, age, level of animal feeding, etc. (Strizhak et al., 2014).

A number of scientists have shown that the assessment of morphological and

biochemical blood parameters in pigs after application of probiotics (Kluczek, 2006), mineral feed additives (Kucheriavyi et al., 2017), biologically active additives (Grushanska et al., 2017), enzyme preparations (Kovalenko et al., 2010; Bankovska et al., 2011; Hutsol, 2013), homogenized feed (Derzhgovsky, 2008) is a necessary study to establish the scientific evidence of the effects on the body of additives used in pig feeding.

In other studies, researchers have shown a correlation between the quality of muscle tissue and the assessment of the biochemical blood parameters in pigs of different categories. Thus, it was found that young pigs of the "low quality" meat category in terms of moisture retention, tenderness, and intramuscular fat content are characterized by a higher content of total protein (0.67–6.73 g/L), the activity of aspartate aminotransferase (0.06–0.31 mmol/h/L) and alkaline phosphatase (4.89–47.56 IU/L) in blood serum compared to peers of the "high quality" category. Significant correlation coefficients were established by pairs of characteristics: "tenderness × cholesterol content" ($r = 0.420 \pm 0.1892$, tr=2.22) and "color intensity, extinction units × 1000 × alkaline phosphatase activity" ($r = -0.483 \pm 0.1826$, tr = 2.64) (Khalak et al., 2017). In this context, the author proved that in young pigs at the age of 6 months albumin concentration ranged from 32.06 to 35.68 g/L with the best values of moisture retention, tenderness, fat content, and color intensity of muscle tissue from longissimus dorsi muscle.

According to the indicators of albumin/globulin ratio in blood serum, it is possible to determine the biological characteristics of pigs of different genotypes in different physiological conditions. Thus, it has been proven that the most precocious animals were from combinations of local sows and local sows with Duroc boars (Kodak, 2011).

Purpose – to determine the morphological and biochemical blood parameters in young pigs under inclusion of LG-Max and Sel-Plex feed additives to the main diet.

Materials and methods of research

Pigs were fed with feed additives as a premix added to the feed to meet the needs of pigs in Omega-3 PUFAs (a daily requirement for Omega-3 in pigs is 672 mg; the experimental feed additive contains 353 mg of Omega-3PUFAs per 1 g).

Based on this, a scheme of the scientific and economic experiment was built. After a 15-day equalization period, 4 groups of analogs from young pigs (5 animals in the control and experimental groups) by origin, age, and live weight were formed. The animals were kept in pens with 5 pigs in each. The experimental groups were formed from wild boars – young castrated male pigs.

According to the experimental scheme, the pigs of the control group were fed the main diet, the animals of the experimental groups – main diet + different amounts of feed additives. Thus, pigs of the 1st experimental group were fed 2.0 g/day of LG-MAX supplemented to the main diet, 2nd experimental group – 4.0 g/day of LG-MAX, and 3rd experimental group – 2.0 g/day of LG-MAX and Sel-Plex (0.5 mg/kg) according to the registration certificate. This article presents the results of a biochemical study of blood serum in pigs of the 2nd experimental (E_2) group (4.0 g/day of LG-MAX feed additive).

Determination of morphological and biochemical blood parameters in young pigs (45-, 120- and 155-day-old) was per-

formed after a 15-day equalization period. To do this, blood samples were taken from clinically healthy pigs. Blood was taken from the marginal ear vein in the morning before feeding (Tkachyk et al., 2019).

For morphological studies, blood was collected in special tubes with Trilon B, and for biochemical – whole blood, which was defended and centrifuged to obtain serum.

The count of white blood cells (WBC) and red blood cells (RBC), hemoglobin content (Hb) were determined on an automatic hematology analyzer PCE 90 Vet.

Serum biochemical parameters were determined using an automatic biochemical analyzer GBG ChemWell 2910 (USA) and using a test system – Global Scientific (USA).

Results of the research and their discussion

Table 1 shows the blood biochemical analysis in pigs under feed supplementation with LG-MAX feed additive (4.0 g/day).

According to the obtained results (Table 1) for 45-day-old pigs of the experimental group, the concentration of β-globulins in blood serum was significantly lower by 1.0% ($P < 0.05$), urea – by 0.44% ($P < 0.01$), phosphorus – by 0.19% ($P < 0.05$), and aspartate aminotransferase (AST) activity – by 12.2% ($P < 0.01$) compared with the control.

An increase in γ-globulin concentration in blood serum compared to that in pigs of the control group indicates the stabilization of immune defense processes.

In general, globulins are a heterogeneous mixture of protein molecules, in which α-, β- and γ-globulins are secreted. Each of these fractions contains specific proteins that perform certain biochemical functions. The composition of this fraction includes transferrin, hemopexin, β2-microglobulin, low-density lipoproteins, components of the complement system (C3). The physiological norm for globulin concentration in blood serum of pigs is from 50 to 65%.

Important for the body of animals are blood γ-globulins, which are the material for the construction of antibodies, as well as α-, β-globulins, which bind such complex compounds as carbohydrates, cholesterol, phosphatase, vitamins, and hormones.

To study the response to changes in animals caused by disease or stress, the albumin/globulin ratio is determined.

Scientists have proved that in young pigs of large white breed of Hungarian selection, the albumin/globulin ratio was 0.5 for the entire study period and had the smallest deviations from the mean, which indicates that for animals of this genotype albumin/globulin ratio is the most stable value and indicates their sufficiently high resistance and adaptability (Kyslynska, 2012).

On the 120th day of the experiment, the content of total protein in blood serum of pigs of the experimental group was significantly higher by 9.48% ($P < 0.001$), γ-globulins – by 2.0% ($P < 0.05$), AST activity– by 3.0% ($P < 0,05$) compared with the control. Instead, the albumin content was significantly lower by 1.8% ($P < 0.05$), glucose – by 0.34% ($P < 0.05$), creatinine – by 43.0% ($P < 0.001$), cholesterol – by 0.54% ($P < 0.001$), and alkaline phosphatase – by 34.6% ($P < 0.001$) compared with the control.

The increase in total protein content can be explained by the fact that blood proteins are able to provide the body with the disease resistance, building muscle tissue. Intensively growing animals have higher levels of total protein (Vognivenko et al., 2015).

It is known that albumins are simple globular proteins that play an important role in the body, namely: involved in maintaining oncotic blood pressure, therefore, when the concentration of albumin is less than 30 g/L, the oncotic pressure decreases and edema occurs. Albumins bind and transport free fatty acids. This binding reduces the concentration of physiologically active free fatty acids by 10,000 times. Therefore, a decrease in the amount of albumin may be one of the reasons for the development of fatty infiltration of the liver. Perform accumulative and plastic functions. A significant decrease in the concentration of albumin (up to 5 g/L) is possible for kidney disease with severe nephrotic syndrome.

One of the important components of protein metabolism in blood serum are transamination enzymes, especially aspartate and alanine aminotransferase. These enzymes are catalysts for the amine group transfer reaction between amino and keto acids resulting in the formation of new amino acids, i.e. protein synthesis. The higher their concentration, the higher the activity of a particular metabolic process, the more active the enzyme, the more intense are the metabolic processes in the body (Voloshchuk, 2018).

Before slaughter of pigs on the 155th day of the experiment, the concentration of γ-globulins significantly increased by 2.8% ($P < 0.05$) and Alb/Glo ratio – by 0.22% ($P < 0.05$). However, the content of urea was significantly higher by 1.24% ($P < 0.01$), calcium – by 0.22 ($P < 0.05$), and chloride – by 2.6% ($P < 0.05$) compared with the control. At the same time, the cholesterol content was significantly lower by 0.66 ($P < 0.01$) and iron – by 2.94% ($P < 0.001$) compared with the control.

It is known that urea is the end product of protein metabolism, the main component of residual nitrogen in mammalian blood. The concentration of urea depends on the intensity of its synthesis and excretion, so it is an important test to assess both the function of the liver where it is synthesized and the kidneys through which it is excreted (Novikova, 2013). An important indicator of the state of metabolic processes, animal growth, ensuring the synthesis of biologically active compounds, the ability to bind toxic substances and disinfect them, participation in the formation of bile acids, vitamin D, hormones, and gonads, is cholesterol.

It is known that unsaturated fatty acids affect the normalization of blood vessel walls, increasing their elasticity and reducing permeability, as well as promote the rapid conversion of cholesterol into folic acid and their excretion from the body. Unsaturated fatty acids have been linked to cholesterol metabolism.

The results obtained for a significant decrease in cholesterol level in blood serum of pigs of all experimental groups may indicate an increase in the formation of muscle tissue and a decrease in the adipose tissue when used in the feeding of LG-MAX and Sel-Plex organic feed additives. It is also possible that the regulation of lipid metabolism is due to the content of Omega-3 PUFA in LG-MAX feed additive. Also, it may be similar to the use of fermented feed in pigs (Zinoviev, 2011) and the beginning of lipid deposition in the fat depot, and, therefore, they are found in smaller quantities in blood serum of these animals (Vikulina, 2008).

According to other studied indicators (Table 1), there is a tendency to change between the experimental group and the control.

1. Biochemical parameters of pig blood serum under feed supplementation with LG-MAX feed additive (4.0 g/day), M ± m, n = 5

Parameter	Group					
	Control 45 days	E_2 45 days	Control 120 days	E_2 120 days	Control 155 days	E_2 155 days
Total protein, g/L	51.24 ± 0.80	51.94 ± 1.44	73.00 ± 0.16	79.92 ± 1.05***	76.80 ± 0.81	77.44 ± 0.79
Albumin, %	59.40 ± 1.08	60.20 ± 0.86	52.60 ± 0.40	50.80 ± 0.49*	48.60 ± 0.51	50.40 ± 0.93
Globulins, %	41.20 ± 0.86	39.80 ± 0.86	50.0 ± 1.70	50.00 ± 0.63	54.40 ± 1.21	52.00 ± 0.89
α1-globulins	3.60 ± 0.24	3.40 ± 0.24	3.40 ± 0.40	3.40 ± 0.24	3.80 ± 0.37	3.20 ± 0.20
α2-globulins	14.40 ± 0.24	15.20 ± 0.37	17.40 ± 0.51	15.20 ± 1.07	19.40 ± 1.50	16.60 ± 1.03
β-globulins	10.60 ± 0.24	9.60 ± 0.24*	16.60 ± 0.51	16.80 ± 0.58	19.20 ± 0.86	18.00 ± 0.45
γ-globulins	10.80 ± 0.58	10.40 ± 0.24	9.60 ± 0.51	11.60 ± 0.68*	8.20 ± 0.58	11.00 ± 0.89*
Alb/Glo ratio	1.54 ± 0.03	1.59 ± 0.03	1.05 ± 0.23	1.04 ± 0.02	0.89 ± 0.02	0.96 ± 0.08
Glucose, mmol/L	6.26 ± 0.05	6.34 ± 0.20	6.94 ± 0.09	6.60 ± 0.09*	6.46 ± 0.14	6.44 ± 0.14
ALT, U/L	41.00 ± 0.71	40.40 ± 0.51	46.20 ± 0.37	47.00 ± 2.17	46.80 ± 1.39	47.20 ± 1.77
AST, U/L	76.60 ± 1.47	64.40 ± 2.01**	66.40 ± 0.51	68.40 ± 0.51*	63.60 ± 1.81	67.00 ± 0.84
Urea, mmol/L	2.72 ± 0.06	2.28 ± 0.09**	4.68 ± 0.24	4.56 ± 0.22	4.72 ± 0.12	5.96 ± 0.25**
Creatinin, μmol/L	102.20 ± 3.75	99.20 ± 5.70	116.0 ± 4.51	73.00 ± 1.41***	162.00 ± 5.13	164.40 ± 2.86
Cholesterol, mmol/L	2.54 ± 0.16	2.58 ± 0.15	2.94 ± 0.07	2.40 ± 0.071***	2.94 ± 0.13	2.28 ± 0.09**
Alkaline phosphatase, U/L	167.40 ± 2.09	172.00 ± 1.89	165.80 ± 1.94	131.20 ± 2,22***	155.20 ± 3.92	153.0 ± 1.70
Bilirubin, mmol/L	3.80 ± 0.49	4.00 ± 0.71	5.60 ± 0.24	4.80 ± 0.37	6.00 ± 0.71	7.00 ± 0.45
Amylase, U/L	2145.20 ± 194.80	1914.40 ± 97.94	845.40 ± 30.24	783.20 ± 30.86	797.80 ± 36.23	857.60 ± 15.03
Calcium, mmol/L	2.45 ± 0.02	2.41 ± 0.04	2.50 ± 0.04	2.48 ± 0.03	2.42 ± 0.01	2.64 ± 0.07*
Phosphorus, mmol/L	1.72 ± 0.07	1.53 ± 0.03*	2.00 ± 0.07	2.20 ± 0.07	2.42 ± 0.12	2.14 ± 0.07
Potassium, mmol/L	4.08 ± 0.18	4.14 ± 0.14	4.96 ± 0.07	4.84 ± 0.07	5.18 ± 0.08	5.22 ± 0.07
Iron, mol/L	25.70 ± 0.60	23.80 ± 0.97	24.48 ± 0.78	26.50 ± 0.57	28.08 ± 0.01	25.14 ± 0.58***
Sodium, mmol/L	142.20 ± 1.07	145.40 ± 1.21	145.20 ± 0.86	147.00 ± 0.71	147.80 ± 1.36	145.00 ± 0.84
Chlorides, mmol/L	99.00 ± 1.09	99.00 ± 1.30	104.80 ± 1.39	107.00 ± 0.71	103.00 ± 0.71	105.60 ± 0.51*
Magnesium, mmol/L	1.22 ± 0.11	1.30 ± 0.10	1.54 ± 0.12	1.32 ± 0.12	1.88 ± 0.09	2.00 ± 0.07

Note: * $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$ compared with the control of the corresponding age.

Conclusions and future perspectives

When using in pig feeding LG-MAX feed additive in a dose of 4.0 g/day, the biochemical blood parameters in pigs of the experimental groups compared with the control, were within physiological limits according to the age of the animals.

At the same time, during the experimental period, it was found that the biochemical parameters in blood serum of pigs of the experimental group compared with the control of the appropriate age are in the following dynamics: in pigs aged 45 days, the concentration of β-globulins is significantly reduced and the content of aspartate aminotransferase, urea, and phosphorus is reduced; in 120-day-old pigs, significantly increases the content of total protein, the concentration of γ-globulins and aspartate aminotransferase, significantly decreases the content of albumin, glucose, creatinine, cholesterol, and alkaline phosphatase; in 155-day-old pigs, the concentration of γ-globulins and albumin/globulin ratio significantly increases and urea, calcium and chloride content increases; cholesterol and iron levels were significantly lower.

Further plans include histological examination of the liver in young pigs when feeding different amounts of this feed additive.

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Анотація. *Набутий вітчизняний та зарубіжний досвід розвитку свинарства, підвищення продуктивності тварин і зниження собівартості свинини на 65–70% і більше визначається науково-обґрунтованою годівлею. Водночас, за біохімічними показниками сироватки крові свиней можна оцінити функціональний стан організму та прогнозувати їхню продуктивність і якість м'яса.*

Метою дослідження було визначити морфологічні та біохімічні показники крові молодняку свиней за додавання до основного раціону кормових добавок LG-Max і Сел-Плекс.

Згідно зі схемою дослідження свиням контрольної групи згодовували корми основного раціону, тваринам дослідних груп – різну кількість кормових добавок. Так, групі Д1 до основного раціону згодовували 2,0 г/добу добавки LG-MAX, групі Д2 – 4,0 г/добу добавки LG-MAX, а групі Д3 – 2,0 г/добу добавки LG-MAX і Сел-Плекс (0,5 мг/кг) відповідно до реєстраційного посвідчення. У цій статті наведено результати біохімічного дослідження сироватки крові свиней групи Д2 – 4,0 г/добу добавки LG-MAX.

За застосування в годівлі свиней кормової добавки LG-MAX 4,0 г/добу біохімічні показники крові свиней дослідних груп, порівнюючи з контрольною, були у фізіологічних межах, відповідно віку тварин.

Водночас, упродовж періоду дослідження встановили, що біохімічні показники в сироватці крові дослідної групи свиней порівнюючи з контрольною відповідного віку перебували в такій динаміці: у свиней 45-добового віку достовірно знижується концентрація β-глобулінів і зменшується вміст аспартатамінотрансферази, сечовини та фосфору; у свиней 120-добового віку достовірно підвищується вміст загального білка, концентрації γ-глобулінів і аспартатамінотрансферази, зменшується вміст альбумінів, глюкози, креатиніну, холестеролу й лужної фосфатази; у свиней 155-добового віку достовірно підвищується концентрація γ-глобулінів і коефіцієнт альбумін/глобулін і збільшується показник вмісту сечовини, кальцію і хлоридів, достовірно меншим був показник вмісту холестеролу та Феруму.

Ключові слова: *біохімічні показники, сироватка крові, кормова добавка LG-MAX*

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PERIODONTAL DISEASES IN DOGS (ETIOLOGY, CLINICAL SIGNS, DIAGNOSIS)

M. A. KULIDA, *Candidate of Veterinary Sciences, Associate Professor,*
Department of Surgery and Pathophysiology
named after Academician I. O. Povazhenko
https://orcid.org/0000-0001-8937-1972
National University of Life and Environmental Sciences of Ukraine, Kyiv, Ukraine
E-mail: mkulida@ukr.net
S. M. TKACHENKO, *Candidate of Veterinary Sciences, Associate Professor,*
Department of Surgery and Pathophysiology
named after Academician I. O. Povazhenko
https://orcid.org/0000-0002-2775-1387
National University of Life and Environmental Sciences of Ukraine, Kyiv, Ukraine
E-mail: tkachenko_sm@nubip.edu.ua

Abstract. *Recently, the number of non-communicable pathologies in dogs is increasing and a large part of them are caused by diseases of the oral cavity area. A significant number of them are dental problems. One of them is periodontitis.*

More often periodontitis occurs as a result of tooth fractures and the development of caries, which are complicated by necrotic pulpitis. The main forms of periodontitis in dogs: fibrous, granulomatous, granulating, and suppurative.

The work describes clinical manifestations of periodontal pathology and interprets the radiological images taken for final diagnosis of oral cavity pathology.

Fibrous periodontitis was found to be asymptomatic and characterized by insignificant equitable expansion of the periodontal slit in the apex area. Granulating periodontitis is characterized by hyperemia and swelling of the mucous membrane of the gums in the area of tooth root projection and uneven jaw bone destruction with deformation of the periodontal slit. Granulomatous periodontitis is asymptomatic and is characterized by the development of a rounded defect of the jaw bone, which is associated with periodontitis and is radiologically detected. A fistula in the infraorbital region (fourth upper premolar) is observed quite often. In cases of suppurative periodontitis in dogs, toothache, hyperemia and swelling of the gums, fistula, destruction and melting of the periodontal ligament were noted.

Odontogenic abscesses can be considered not only as an independent nosologic unit but also as a kind of suppurative periodontitis. Granulomas of periodontal tissue are a part of chronic periodontitis including its similar etiology, pathogenesis, symptoms, and localization.

Keywords: *fistulas, caries, tooth fractures, deformation, periodontal slit*

Introduction

Recently, the number of non-communicable pathologies in dogs has been increasing, the majority of which are caused by diseases of the oral cavity. A significant number of them are dental problems.

One of them is periodontitis, which is widespread in 15–23% of cases (Borisevich, 1997; Lovegrove, 2004) among dental diseases in dogs, and according to Petrenko (1998), this pathology constitutes 7% of all dental diseases in veterinary medicine.

The main etiological factors of periodontal diseases are dental trauma followed by penetration of infection into the tissues of the oral cavity through the tooth or by the hematogenous route. But the presence of dental calculus can also be a source of infection.

Regardless of the causes of occurrence, periodontal pathology has clinical signs that are manifested by symptoms of inflammation, which must be differentiated from other pathologies in the oral cavity. In each particular case, it is necessary to combine different methods of diagnostics to clarify the diagnosis, which is important both for practicing veterinarians and scientists.

Analysis of recent researches and publications

The root of the tooth is connected to the bone tissue of the jaw by the connective tissue sheath, which is called periodontium (Small, 1967). The periodontium is a connective tissue located between the root and the dental alveolus. Physiologically, the structure of the periodontium corresponds to the structure of the periosteum (Nimand & Suter, 1998).

The important function of the periodontium in animals is the retention and cushioning of the teeth because the teeth of predators are subjected to different loads during the retention of prey or the gnawing of bones.

Periodontitis is the inflammatory process in the structures of the periodontal tissues – periosteal inflammation in the tooth root area, i.e. inflammation of the periodontium (Lukyanovsky et al., 1988; Frolov, 2003).

Periodontitis apart from inflammation of the periodontium is also characterized by inflammation of the periosteum, which can be marginal, apical, or diffuse (Belov et al., 1990; Pinto et al., 2020). Periodontal disease is divided into acute and chronic, and into aseptic and purulent (Nises et al., 2018).

Periodontal diseases also include odontogenic abscesses, which according to Frolov (2003) have a prevalence of up to 10% of clinical cases. They occur as a result of the penetration of microorganisms into the tissues of the jaw around the tooth by exogenous or endogenous route (Pavlica et al., 2008). This results in the melting of some tissues with clearly demarcated purulent inflammation and necrosis (Simpson et al., 2003; Frolov et al., 2003, 2006; Wallis et al., 2015).

Granulomas of periodontal tissue occur in dogs not more often than abscesses and are characterized by peri-apical proliferative inflammatory processes, which lead to local bone resorption (Small, 1967; DeBowes et al., 1996). In this case, there is a spread of infection, colonization by secondary microflora, accumulation of decay products, and alveolar pyorrhea (Enlund et al., 2020). Pus may come out of the formed fistula into the oral cavity, alveolus of the tooth but its release is often visible with the penetration of the skin under the eye or in the nose (Simpson et al., 2003; Garanayak et al., 2019).

According to Loesche (1985), periodontal disease is a combined term given to the different inflammatory conditions of the tissue, which support and bond the teeth to the jaw bone. The inflammatory reaction occurs to bacterial products and/or bacteria that enter the tissues from the dental plaque.

Dental plaque is a complex microbial community containing about 190 different taxons that exist on dental surfaces (Harvey, 1998). Until recently, there were few consensus pathogens, and trying to distinguish pathogenic from nonpathogenic was a difficult task for dental researchers for a variety of reasons (Joanne et al., 2004). Periodontal disease is widespread and often has a very severe course in dogs. This is caused by the accumulation of bacterial plaque, especially gram-negative anaerobic rods. Tissue rupture results from autodegradation caused by an ongoing inflammatory reaction. Small dogs are, particularly, at risk. Prophylaxis by slowing the accumulation of plaque is a key concept (Harvey, 1998).

The results of the research show that there is a relationship between the predicted "burden of periodontal disease", which is caused by periodontal diseases associated with bacterial plaque, and the level of internal pathology in the examined group of animals, bearing in mind that periodontitis can contribute to the development of systemic pathology in dogs (Pavlica et al., 2008).

Thus, the analysis of literary sources shows that the issues of etiology, treatment, symptoms, and diagnostics of canine periodontal diseases are insufficiently covered in the Ukrainian veterinary community. It should also be noted the contradictions in the classification of these pathologies.

Purpose. To investigate etiology, symptoms, and to conduct radiological examination in dogs with different forms of periodontitis.

Materials and methods of research

The work was carried out on the basis of the veterinary and surgical center "Chance", located in Kyiv on Volzka Street. Among the animals admitted to the reception according to the results of the clinical examination, 20 dogs with the final diagnosis "periodontitis" were selected.

Animals for study were selected according to the results of the clinical examination in dogs by the generally accepted methods taking into account anamnestic data. Special attention was paid to the examination of the oral cavity, the condition of the mucous membrane of the oral cavity was determined: gums, hard and soft palate. The position, shape, color, the number of teeth and their mobility were determined. Probing of carious cavities on toothless areas was performed, alveoli were examined.

Radiography of organs of the maxillofacial system is one of the most widely used methods of examination. Radiography gives valuable information about the condition of hard tissue of the crown and root, size and features of the tooth cavity, root canals, width and character of the periodontal slit, condition of the compact plate of an alveolar wall and spongy part of the alveolar process. That is why to clarify the diagnosis we carried out a radiological examination of the oral cavity in dogs using extraoral imaging in rigid cassettes and intraoral – in small cassettes. Apart from intraoral (focused) imaging, the pantomography method was used, which allows obtaining panoramic radiographs of dental rows and jaws. Using extraoral radiography (in different settings), we examined areas of the upper and lower jaws, the temporomandibular joint, and the bones of the facial part of the skull.

Results of the research and their discussion

All cases of periodontitis manifested themselves by the presence of caries or old tooth fractures with pulp exposure. These pathologies were accompanied by necrotizing pulpitis. The manifestation of the disease in the animals was not dependent on the breed or gender characteristics of the dogs. The age of the diseased animals varied from 5 to 12 years. Localization and causes of periodontitis in the studied dogs are given in Table 1.

Our tests showed that the causes of periodontitis in dogs were tooth fractures in 75% of the animals and dental caries in only 25% of cases.

All the animals that had tooth fractures showed tooth deformation as a result of complete or partial loss of the crown, presence of the broken surface, the area of pulp exposure, and in case of caries, the destruction of the crown and the softening of the walls and bottom of its cavity, and penetration into the pulp chamber is marked.

During the examination with periodontal instruments, the pulp was removed in pieces, grayish-black in color, without bleeding, indicating its necrosis.

Animals with oral cavity pathology underwent radiological examination.

X-ray images clearly showed violations of the anatomical shape of the tooth and pathological processes in the periodontium, which varied depending on the form of the disease.After conducting all the necessary examinatons, the following forms of periodontitis were identified in the studied dogs: fibrinous, granulating, granulomatous, and purulent.

Fibrinous periodontitis was observed in 7 cases (5 fourth premolars and two canines). At the same time pain was absent, with their mobility and change of gingival tissues. On X-ray images – slight uniform expansion of the periodontal slit around the apex of the root in the form of a strip in the area of the apex, which was limited by the contours of the tooth and the uneven line of the compact plate of the jaw bone (Fig. 1).

Granulating periodontitis was observed in two cases (fourth premolars with fistulas). During the examination of this group, there was no tooth pain, the teeth were undisturbed, there was a slight hyperemia and swelling of the gingival mucosa at the site of the tooth root projection. On the X-ray images, we observed uneven enlargement and deformation of the periodontal slit near the root apex with jaw bone rupture, osteolysis manifested as a darkened area near the apex with blurred edges. A characteristic feature was an uneven toothed line of a compact lamina of the tooth sockets with sites of wedge-shaped entrance into it of the periodontium (Fig. 2). Granulomatous periodontitis

1. Localization and causes of periodontitis in dogs (M ± m, n = 20)

The cause of periodontitis	Jaw	Tooth type	Number of occurrences	%
Caries	Upper	1st molar	4	20
		4th premolar	1	5
Tooth fractures	Upper	Canines	2	10
		4th premolar	9	45
	Lower	Canines	4	20

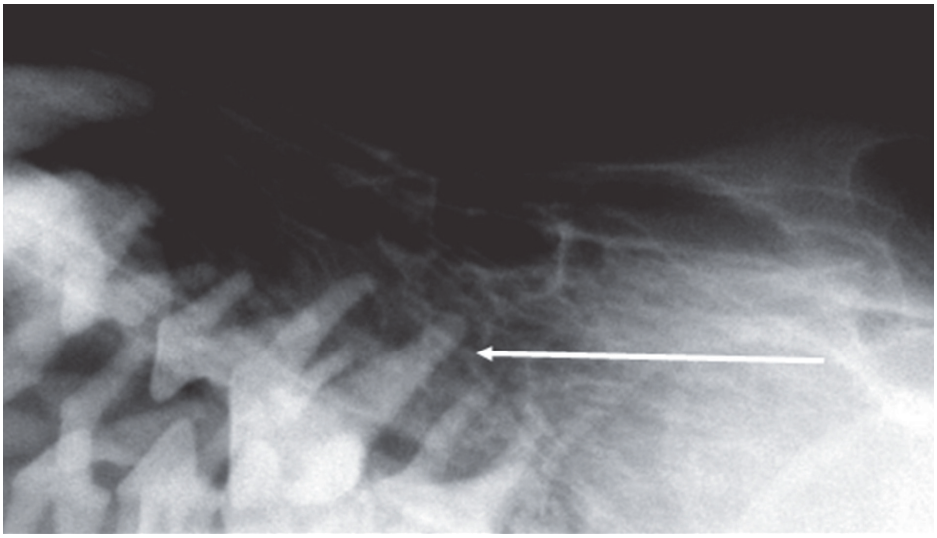

Fig. 1. Fibrous periodontitis of the fourth upper premolar

was observed in 8 animals (four canines and four fourth premolars). In this group, oral cavity examination did not show tooth pain, and there were no changes in the tooth mobility and the gingival tissues. Three dogs with premolar fractures were found to have fistulas in the periorbital region, with swelling and pain in the eyelids (the fistulas disappeared after tooth extraction).

X-rays revealed granulomas attached to the tooth root in the bone (in the form of a sac), which appeared as intense rounded darkening in the jaw, connected with the tooth root, clearly separated from the surrounding tissues (Fig. 3).

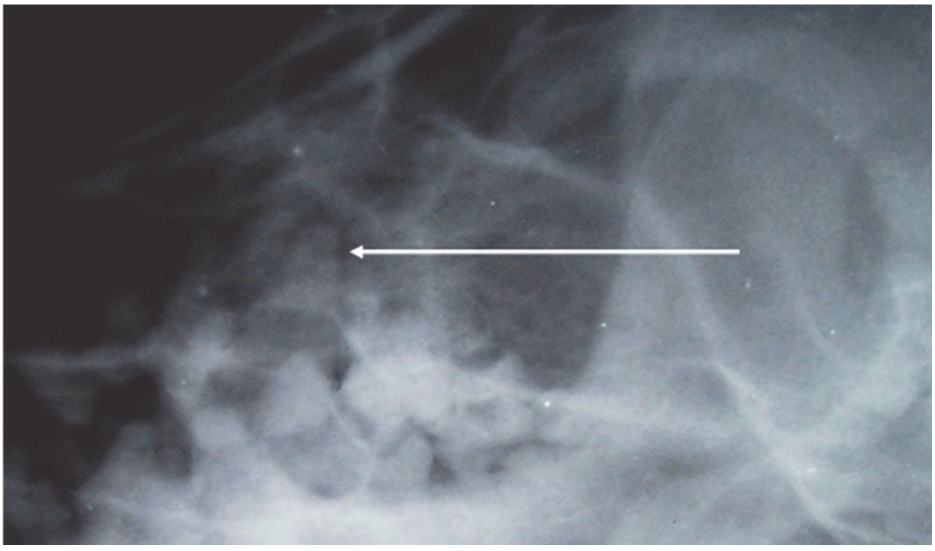

Fig. 2. Granulating periodontitis of the fourth upper premolar

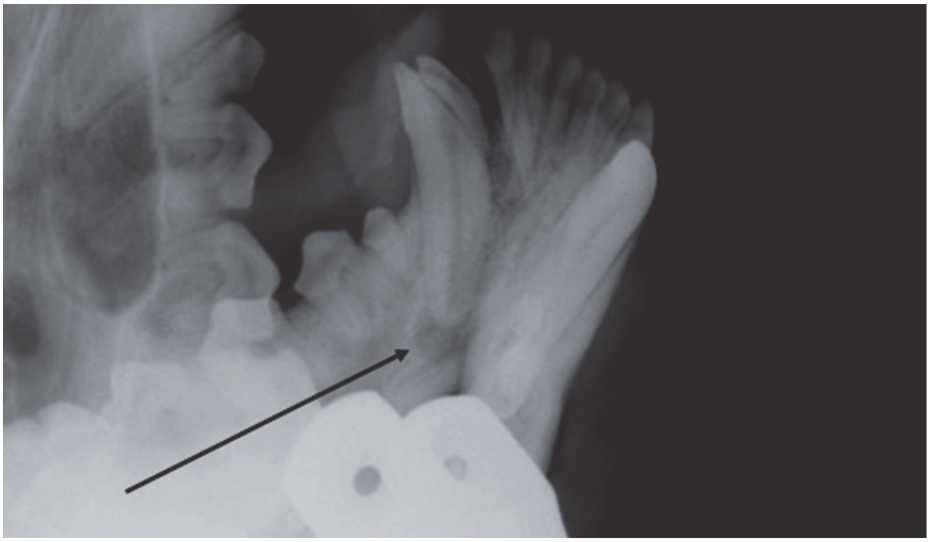

Fig. 3. Granulomatous periodontitis of the lower canine

The digital image clearly shows a thin opening of the fistula, which stretched cranially along the maxillary bone. In acute suppurative periodontitis, local and general manifestations of pain are pronounced. Pain sensations increase. As a result of the purulent melting of the ligamentous apparatus, the tooth becomes mobile.

Acute suppurative periodontitis is sometimes accompanied by the appearance of collateral edema in the soft tissues of the head and hyperemia of the gums in the area of the diseased tooth forming an abscess.

Fig. 4. Turgidity in the infraorbital region with swelling of eyelids due to suppurative periodontitis of the fourth upper premolar in a dog

Suppurative periodontitis was observed in three animals (in two of them – the first premolar, in one – the fourth premolar of the upper jaw) as a result of caries. Toothache, hyperemia, and swelling of gums were noted. When the upper premolars are affected – fistula in the infraorbital region with swelling of eyelids and abscesses (Fig. 4).

In chronic periodontitis, we noted changes in the position of teeth, increased degree of their mobility, the appearance of interdental fissures. With exacerbation of periodontitis, the bleeding of the gums was observed. In advanced cases, the external output of purulent exudate with disruption of the integrity of the skin covering in the area between the lower eyelid and the upper jaw (formation of fistulas) was observed.

When caries of the fourth premolar, there was strong mobility of the tooth, the gums were detached from its neck and the release of purulent exudate was seen, and when caries of the canines, the gums were detached from the neck of the tooth (Fig. 5).

The previous diagnosis was made on the basis of oral cavity examination. Attention was paid to the presence of swelling of the salivary glands, lymph nodes, dental calculus, and gingivitis. Residual conclusions were made after oral cavity examination under general anesthesia (the degree of dental calculus formation, the depth of periodontal pocket were determined).

Conclusions and future perspectives

The main cause of periodontitis in dogs is tooth fractures and caries, which are complicated by necrotic pulpitis.

Fibrous periodontitis has an asymptomatic course and is characterized by a slight equitable expansion of the periodontal slit in the apex area.

Granulating periodontitis is characterized by hyperemia and swelling of the gingival mucosa at the site of the tooth root projection and uneven destruction of the jaw bone with deformation of the periodontal slit.

Fig. 5. Gum detachment from the neck of the tooth

Granulomatous periodontitis has an asymptomatic course and is characterized by the development of a rounded defect of the jaw bone associated with periodontitis that is radiologically detected. Fistulas in the infraorbital region (fourth upper premolar) may sometimes be observed.In case of suppurative periodontitis in dogs, a toothache, hyperemia and swelling of the gums, fistulas, destruction and melting of the periodontal ligament are noted.

Odontogenic abscesses can be considered not only as an independent nosologic unit but also as a kind of suppurative periodontitis. Granulomas of periodontal tissue are a form of chronic periodontitis, taking into account their similar etiology, pathogenesis, symptoms, and localization.

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Анотація. *Останнім часом збільшується кількість незаразних патологій собак, серед яких доволі великий відсоток припадає на хвороби в ділянці ротової порожнини. Значну кількість серед них займають стоматологічні проблеми. Однією з них є періодонтит.*

Частіше періодонтити виникають унаслідок переломів зубів та розвитку карієсу, які ускладнюються некротичним пульпітом. Основні форми періодонтитів у собак: фіброзний, гранулематозний, гранулюючий та гнійний.

У роботі описано клінічні прояви патологій періодонта та проведено інтерпретацію рентгенологічних знімків, які зробили для остаточної діагностики патологій ротової порожнини.

Встановлено, що фіброзний періодонтит має безсимптомний перебіг і характеризується незначним рівномірним розширенням періодонтальної щілини в ділянці апекса. За гранулюючого періодонтиту спостерігали гіперемію та набряк слизової оболонки ясен у місці проєкції кореня зуба та нерівномірне руйнування щелепної кістки з деформацією періодонтальної щілини. Гранулематозний періодонтит має безсимптомний перебіг і характеризується розвитком округлого дефекту щелепної кістки, який пов'язаний із періодонтитом і виявляється рентгенологічно. Досить часто спостерігали утворення нориці в підочній ділянці (четвертий верхній премоляр). Під час гнійного періодонтиту в собак відзначали болючість зубів, гіперемію і набряк ясен, нориці, руйнування та розплавлення періодонтальної зв'язки.

Зважаючи на це, одонтогенні абсцеси можуть розглядатися не тільки, як самостійна нозологічна одиниця, а й як різновид гнійного періодонтиту, відповідно гранульоми періодонтальної тканини – як форма хронічного періодонтиту, що, на нашу думку, є більш обґрунтованим, з огляду на їхню подібну етіологію, патогенез, симптоми та локалізацію.

Ключові слова: *нориці, карієс, переломи зубів, деформація, періодонтальна щілина*

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A CLINICAL CASE OF THE TREATMENT OF THE SPINE TRAUMA WITH SPINAL CORD INJURY IN CAT

V. O. DOROSHCHUK, *Candidate of Veterinary Sciences, Associate Professor,*
Department of Surgery and Pathophysiology
named after Academician I. O. Povazhenko
https://orcid.org/0000-0003-2826-5740
National University of Life and Environmental Sciences of Ukraine, Kyiv, Ukraine
A. I. SOKOL, *Graduate student, Department of Surgery and Pathophysiology*
named after Academician I. O. Povazhenko
https://orcid.org/0000-0002-2968-5934
National University of Life and Environmental Sciences of Ukraine, Kyiv, Ukraine
E-mail: dorviktor@gmail.com

Abstract. *The article covers a clinical case of spine trauma with spinal cord injury in a cat. He was diagnosed with a bullet wound to the lumbar spine with spinal cord compression. Dorsal laminectomy was performed with the removal of the bullet at the L3–L5 level. The surgical intervention was performed without complications with a complete recovery of the animal after 2 months.*

Because the prognosis of functional recovery remains cautious in spinal cord injuries without deep pain perception, as spinal cord function is completely blocked, it is important to note that nociceptive pathways are most resistant to compression and ischemia. It is established that for the diagnosis and control of the treatment results for spinal cord injuries in cats, the most appropriate is an X-ray examination of the damaged areas in lateral and dorsoventral projections using an X-ray contrast agents (myelography).

Laminectomy, which involves the partial or complete removal of an element that causes a compression effect, allowing additional free space to form for the spinal cord, is an effective method for treating spine injuries and spinal cord traumas in cats. Additional stabilizing systems are used to fix the spine and preserve its functions. Laminectomy allows eliminating the pressure of other anatomical structures on the spinal cord of the animal and nerve endings by resection of the vertebral arches in the affected area, their spinous processes, intervertebral discs, etc. The restoration of the functional state of the animal requires a comprehensive application of rehabilitation measures, such as control of motor activity of the animal (namely its restriction), massage, physiotherapy procedures aimed at reducing pain and improving blood circulation in the injured area.

Keywords: *spine, vertebra, laminectomy, cat, trauma, spinal cord*

Introduction

Currently, in Ukraine, animals are not fully protected from cruelty, so cases of trauma to small animals are common in the practice of a veterinarian. Due to the constant urbanization of polytrauma in animals are quite common. They are most often associated with a fall from a height or injury from a car accident. Due to the availability of air guns, the number of cases of bullet wounds has increased.

After a spinal cord injury, one of the main problems for cat owners is whether their cat will be able to fully recover (ability to walk, maintaining the functions of self-selection). Unfortunately, in fact, the most common is "suboptimal recovery", when weakness and urinary incontinence in animals persist forever.

Analysis of recent researches and publications

In general, in any patient with a spinal cord injury with paraplegia/tetraplegia without a deep perception of pain, the prognosis of functional recovery remains cautious because spinal cord functions are completely blocked or intersect at the site of injury (Olby, 2012). It should be borne in mind that the nociceptive pathways are the most resistant to compression and ischemia. Further examination is required to confirm the integrity of the spinal cord. Thorough neurological examination is fundamental to assess spinal cord function and provide the client with a prognosis (Zamprogno et al., 2010).

Injured animals in shock should be treated before assessing spinal cord function. Tactics for treating such animals should always be based on the assumption that the spine is unstable, so care should be taken when manipulating or moving the patient (Knipe et al., 2001). After stabilization of vital signs, a review radiograph (2 projections: lateral and dorsoventral) of the entire spine is usually performed, as approximately 20% of patients with spinal cord injury have multiple vertebral fractures or dislocations (Jeffery, 2010). Instrumental research methods may include plain radiography, myelography (contrast radiography or spondylography), computed tomography, magnetic resonance imaging. Diagnostic imaging is the most important step in making a diagnosis. However, plain radiography is characterized by low sensitivity in identifying a pathological disc (55–60%), therefore, this method is advisable to use for screening diagnostics in order to exclude fractures (Schur et al., 2010).

Laminectomy is the partial or complete removal of an element that causes a compression effect, allowing the formation of additional free space for the spinal structures (Kranenburg et al., 2012). Additional stabilizing systems are used to fix the spine and preserve its functions (Sharp & Wheeler, 2005). Laminectomy allows eliminating the pressure of other anatomical structures on the spinal cord of the animal and nerve endings by resection of the vertebral arches in the affected area, their spinous processes, intervertebral discs, etc. (DiFazio & Fletcher, 2013). Thanks to these measures, it is possible to eliminate pressure on sensitive spinal structures and to release the clamped nerve endings releasing an animal from the expressed pain, and also paresthesias and paresis (Yadhati et al., 2017).

Purpose. To determine the most optimal algorithm for the diagnosis and treatment of spine trauma with spinal cord injury in cats. To raise the awareness of veterinary practitioners about the most effective methods for treating complex spine traumas with spinal cord injury in cats.

Materials and methods of research

The private veterinary clinic in Kyiv received an animal: a cat, age 8 months, male, half-breed, with signs of trauma to the spinal canal (penetrating hole, probably a bullet in the lumbar region). The clinical examination revealed complete paralysis of the pelvic limbs, the absence of any reflexes and types of sensitivity. Research methods are clinical and instrumental (radiological). The animal underwent myelography. Before myelography, we performed neuroleptoanalgesia with Meditin at a dose of 1.0 mg/kg. For premedication, we used atropine at a dose of 0.5 mg/kg. Immediately after the neuroleptoanalgesia, we intubated the animal, which made it possible to immediately resort to artificial ventilation in case of respiratory arrest.

When contrasting the cerebrospinal fluid spaces of the spinal cord, a very important step is to calculate the dose of a radiopaque substance. With an increase in concentration, the quality of visualization improves but, at the same time, an increase in the concentration of contrast agents in the liquor spaces increases the risk of complications, allergic reactions, and side effects. Therefore, the choice of radiopaque contrast agents is very important. Based on our own experience, we recommend Omnipaque, which we used at a dose of 1.0 ml per cat.

We performed the caudal approach by subarachnoid injection in the lumbar spine. For this, the animal was fixed in a lateral position by extending the cranial pelvic limbs (so that the animal's spine was in a flexed position). The injection was performed at the L5–L6 level.

Guided by the wings of the ilium, L7 was palpated, located at the level of their cranial edge, and L6, L5, and L4 were identified. Then the needle was inserted in the sagittal plane into the intervertebral space, between the two spinous processes, parallel to the caudally located spinous process. After the sensation of "falling through" of the needle (when the dura mater was punctured), the mandrel was removed and, in the presence of cerebrospinal fluid outflow, a radiopaque substance was injected (Royce et al., 1993).

Contrast radiography was performed on a mobile X-ray machine Fujifilm FCR Go 2 (Japan). Thanks to its high power (max, anode current 250 mA) and a small focal spot size (0.6 mm), the device allows obtaining clear images with a short exposure time.

The animal underwent laminectomy. Meditin, Zoletil, and Sevoflurane were used for anesthesia. The correct position of the animal during the surgery is of great importance and facilitates its implementation.

Results of the research and their discussion

For the most accurate determination of the lesion in the spine, an X-ray examination was performed in lateral projection. After a preliminary X-ray examination in the spinal canal of the animal, a foreign body (bullet) was found in the lumbar region at the L4 level (Fig. 1).

This injury was an open penetrating fracture of the vertebral arch with a large number of fragments, which causes compression of the spinal cord at the L4 level (myelopathy), and radiculopathy due to swelling of the surrounding tissues. In this case, the vertebra itself remains stable relative to others, so it does not require additional fixation. Prolonged compression of the spinal cord can cause irreversible consequences, so medical manipulations should be performed im-

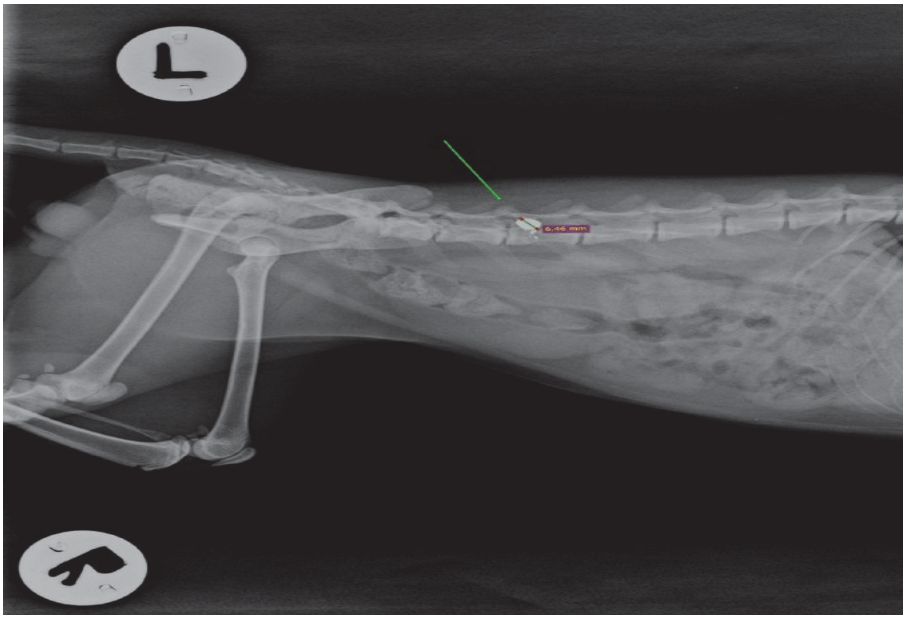

Fig. 1. Radiography of the damaged area of the spine in lateral projection

mediately. Immediately before surgery, myelography with an X-ray contrast agent Omnipaque-300 at a dose of 1.0 ml (Fig. 2) was performed to accurately determine the degree of spinal cord injury, after which the presence of spinal cord compression and narrowing of the spinal canal was established.

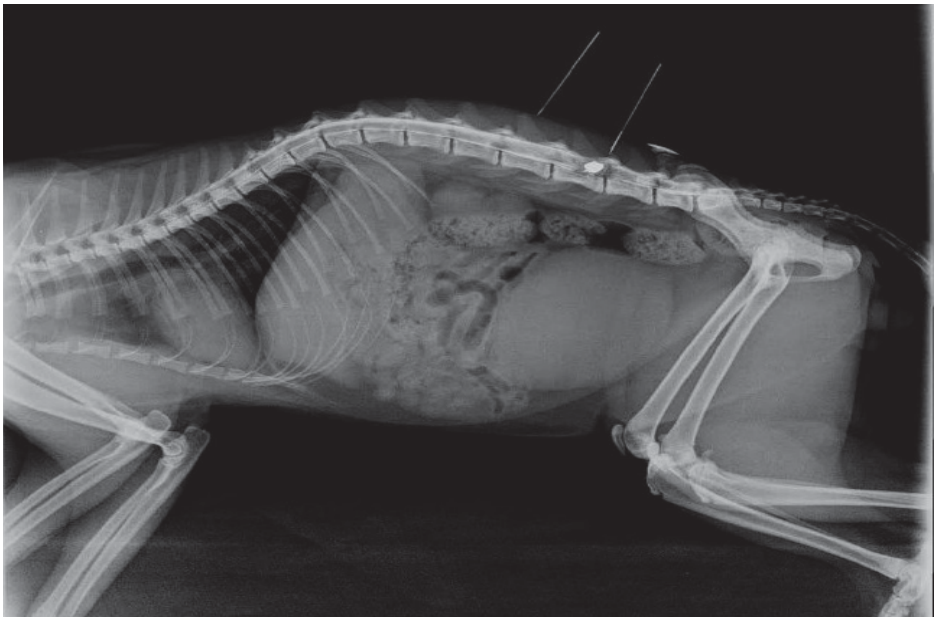

Fig. 2. Myelography of the damaged area of the spine

This figure shows an X-ray image with a contrast agent injected into the subarachnoid space. The radiopaque substance clearly indicates the location of the spinal lesion and the violation of the integrity of the spinal canal.

We removed the bullet and fragments of the vertebral arch, as well as hemilaminectomy to reduce spinal cord compression, during which we removed parts of the arches of two adjacent vertebrae and articular processes (Fig. 3, 4).

Figures 3, 4 show the stages of dorsal laminectomy – separation of soft tissues from the arches and joints of the vertebrae; reaming the contour of the removed part of the vertebral arch with a diamond bur; removal of the vertebral arch and release of the spinal cord from compression; spinal cord imaging and collection of accumulated blood.

The skin was dissected 1–2 vertebrae cranially and 1–2 vertebrae in the caudal area of the injury. Then, the fascia was dissected with a coagulator along the same length. The longest and multifidus muscles were dissected bluntly. The spinous processes were skeletonized from the side of the hemilaminectomy (separating the multifidus muscles with a rasp), the arch of the vertebra, articular processes, pedicles of the arch, transverse or transverse costal processes. When isolating the articular processes, it is necessary to cut the muscles as close to the joint as possible. Into the cranial and caudal wound site, Gelpi retractors were installed. Bleeding was stopped with a coagulator, as well as tight tamponade with 3% hydrogen peroxide or warm saline solution. The bow was removed either with a high-speed bur or, more often, with a laminectomy (Kerrison's nippers) and Jansen's nippers. At the same time, the pressure was not allowed with the instrument on the spinal cord. After the arch was removed, the spinal canal was revised. The wound was sutured in layers.

This figure shows a view of the final stage of the operation and the removed foreign body (bullet).

Subsequently, an X-ray examination was performed after surgery (Fig. 5).

This figure shows an X-ray of a cat 53 days after the surgery. It can be seen that the lumen of the spinal canal is preserved.

In the postoperative period as an anti-inflammatory drug was used "Meloxi-

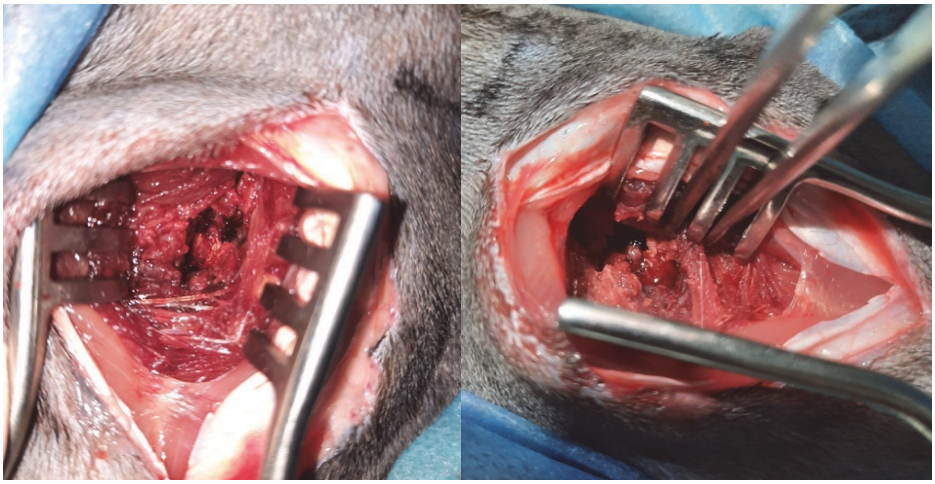

Fig. 3. Stages of laminectomy

Fig. 4. Removed foreign body (bullet)

cam" at a dose of 0.2 mg/kg body weight of the animal for 3 days, for postoperative analgesia was used the drug "Butorphanol" at a dose of 0.1 mg/kg body weight for 5 days. To accelerate the reparative processes in the injured spinal cord was used vitamin preparation "Neurorubin" at a dose of 0.2 ml/kg body weight of the animal, once a day for only 12 days. For the next 30 days the animal was restricted in movement, and after suturing (10 days) was a course of special physical rehabilitation exercises, as well as massage and physiotherapy procedures (iontophoresis with lidocaine, and ultrasonic heating). In 14 days after the surgical intervention, the animal fully restored its independent excretory functions (urination and defecation). After 28 days, a shaky gait was registered in the animal.

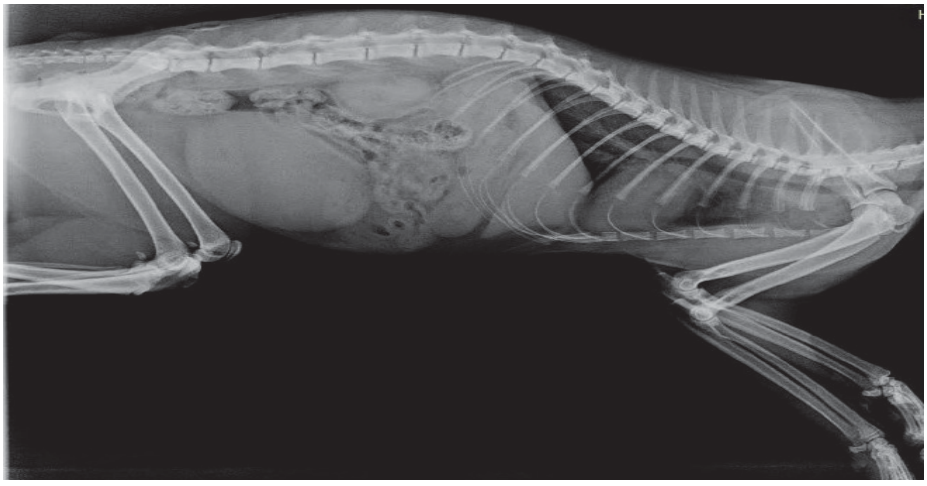

Fig. 5. Radiography of the spine in lateral projection after surgery

Complete recovery of motor activity in the animal was registered on the 53rd day after surgery.

Conclusions and future perspectives

The most appropriate for the diagnosis and control of the treatment results for spinal cord injuries in cats is an X-ray examination of the damaged areas in lateral and dorsoventral projections using an X-ray contrast agents (myelography). Laminectomy is an effective method for treating spine trauma and spinal cord injuries in cats. The restoration of the functional state of the animal requires a comprehensive application of rehabilitation measures, such as control of motor activity of the animal (namely its restriction), massage, physiotherapy procedures aimed at reducing pain and improving blood circulation to the injured area.

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В.О. Дорощук, А. І. Сокол (2021). КЛІНІЧНИЙ ВИПАДОК ЛІКУВАННЯ ТРАВМАТИЗАЦІЇ ХРЕБТА ТА СПИННОГО МОЗКУ У КОТА. *Ukrainian Journal of Veterinary Sciences, 12(1): 32–39, https://doi.org/10.31548/ujvs2021.01.004*

Анотація. *У статті висвітлено клінічний випадок травми хребта з ушкодженням спинного мозку в кота. Було встановлено діагноз кульове поранення поперекового відділу хребта з компресією спинного мозку. Було виконано дорсальну ламінектомію із видаленням кулі на рівні L3–L5. Оперативне втручання було виконано без ускладнень із повним одужанням тварини через 2 місяці.*

Оскільки за травм спинного мозку без глибокого сприйняття болю прогноз функціонального відновлення залишається обережним, оскільки функції спинного мозку повністю заблоковані, необхідно зважати на те, що ноцицептивні шляхи найбільш стійкі до стиснення та ішемії. Встановлено, що для діагностики й контролю результатів лікування травм хребта і спинного мозку в котів найбільш доцільним є рентгенологічне дослідження ушкоджених ділянок у латеральній і дорсовентральній проекціях із застосуванням рентгенконтрастних речовин (мієлографія).

Ламінектомія, що полягає в частковому або повному видаленні елементу, що спричинює компресійну дію, даючи змогу сформувати додатковий вільний простір для спинномозкових структур є ефективним методом для лікування ушкоджень хребта і травм спинного мозку в котів. Для фіксації хребта і збереження його функцій використовуються додаткові стабілізуючі системи. Ламінектомія дає змогу усунути тиск інших анатомічних структур на спинний мозок тварини й нервові закінчення через резекцію дужок хребців у ділянці ураження, їхніх остистих відростків, міжхребцевих дисків тощо. Для відновлення функціонального стану у тварини необхідне комплексне застосування реабілітаційних заходів, таких як контроль рухової активності тварини (а саме її обмеження), масаж, фізіотерапевтичні процедури, спрямовані на зменшення болю та покращення кровообігу ушкодженої ділянки.

Ключові слова: *хребет, хребець, ламінектомія, кіт, травма, спинний мозок*

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A STUDY OF THE EFFICIENCY OF CULTURE MEDIA FOR THE RECOVERY OF LYOPHILIZED PATHOGENIC BACTERIA

V. O. USHKALOV, *Doctor of Veterinary Sciences, Professor*
https://orcid.org/0000-0001-5694-632X
E-mail: ushkalov63@gmail.com
Ukrainian Laboratory of Quality and Safety of Agricultural Products of the National University of Life and Environmental Sciences of Ukraine, Kyiv, Ukraine
L. M. VYGOVSKA, *Doctor of Veterinary Sciences, Research Fellow*
https://orcid.org/0000-0001-6745-5753
E-mail: lnvygovska@gmail.com
Ukrainian Laboratory of Quality and Safety of Agricultural Products of the National University of Life and Environmental Sciences of Ukraine, Kyiv, Ukraine
A. V. USHKALOV, *Candidate of Veterinary Sciences*
https://orcid.org/0000-0001-8317-7909
E-mail: vetdocman@gmail.com
Main Administration of State Service of Ukraine on Food Safety and Consumer Protection in Kharkiv region, Kharkiv, Ukraine
S. O. BOIANOVSKYI, *Junior Research Fellow*
https://orcid.org/ 0000-0002-4621-5192
E-mail: sboyanka@gmail.com
Ukrainian Laboratory of Quality and Safety of Agricultural Products of the National University of Life and Environmental Sciences of Ukraine, Kyiv, Ukraine
A. V. HRANAT, *Junior Research Fellow*
https://orcid.org/0000-0003-3273-903X
E-mail: andriy.hranat@gmail.com
Ukrainian Laboratory of Quality and Safety of Agricultural Products of the National University of Life and Environmental Sciences of Ukraine, Kyiv, Ukraine
S. A. TERESHCHENKO, *Junior Research Fellow*
https://orcid.org/0000-0002-5786-8711
E-mail: kelas1993@gmail.com
Ukrainian Laboratory of Quality and Safety of Agricultural Products of the National University of Life and Environmental Sciences of Ukraine, Kyiv, Ukraine
L. O. DAVYDOVSKA, *Engineer of the 3rd category*
E-mail: li.davydovskaya@gmail.com
Ukrainian Laboratory of Quality and Safety of Agricultural Products of the National University of Life and Environmental Sciences of Ukraine, Kyiv, Ukraine

Yu. Yu. VISHOVAN, *Junior Research Fellow*
https://orcid.org/0000-0003-1128-593X
Ukrainian Laboratory of Quality and Safety of Agricultural Products of the National University of Life and Environmental Sciences of Ukraine, Kyiv, Ukraine
E-mail: anatomi1991@gmail.com

Abstract. *Today, the most appropriate way of long-term storage of most microorganism strains in collections is their lyophilization. The rate and quality of the recovery of biological properties in lyophilized bacterial cultures depend on the quality of culture media used for this purpose. The purpose of this study was to investigate the effectiveness of culture media for the recovery of lyophilized pathogenic bacteria.*

The strains of Salmonella typhimurium, Pasteurella multocida, Yersinia pseudotuberculosis, and Staphylococcus aureus from the collection of the Ukrainian Laboratory of Quality and Safety of Agricultural Products of the National University of Life and Environmental Sciences of Ukraine were used in the study. In order to restore lyophilized bacterial cultures, several variants of culture media were used: meat-peptone broth (Pharmactive, Ukraine) with the addition of 5% equine serum and 0.5% glucose; meat-peptone broth (Pharmactive, Ukraine) with the addition of 5% bovine serum and 0.5% glucose; meat-peptone broth (Pharmactive, Ukraine) with the addition of 5% bovine serum and 0.5% glucose; brain-heart infusion broth (HiMedia, India) and tryptone soya broth (HiMedia, India). Faibich protective medium was used as a cryoprotectant. It was found that in the process of sublimation and cryopreservation of cultures of Salmonella typhimurium, Pasteurella multocida, Yersinia pseudotuberculosis, and Staphylococcus aureus, the loss of viable microbial cells was 99.91–99.98%. The concentration of viable microbial cells in lyophilized cultures of Salmonella typhimurium, Pasteurella multocida, Yersinia pseudotuberculosis, Staphylococcus aureus was recorded in the range of 1.4×10^4–1.7×10^6 *CFU/cm³. During a single passage on different culture media, obtained biomass of the studied cultures was in the initial titer* $x \times 10^9$*. The highest productivity in recovered cultures was obtained using brain-heart infusion broth manufactured by HiMedia, India (concentration of live microbial cells in experimental cultures was recorded in the range of* 5.7–6.4×10^9 *CFU/cm³).*

Keywords: *Salmonella, Pasteurella, Yersinia, Staphylococcus, nutrient media, lyophilization*

Introduction

In order to preserve the activity of microorganism strains, several main methods are used: lyophilization, cryopreservation, freezing of agar media grown bacterial cultures at -70 ºC, periodic reseeding on nutrient media, cultivation in appropriate biological systems (chicken embryos, cell culture, etc.) (Cherkasskiy et al., 1988; Osadchaya et al., 2002; Holovko et al., 2004; Akymenko, 2007; Vygovska et al., 2007; Ushkalov et al., 2009).

To date, the most appropriate way of long-term storage of most microorganism strains in collections is their lyophilization (Akymenko, 2007; Vygov-

ska et al., 2007). For cryopreservation and subsequent freeze-drying, it is recommended to use cells in the stationary phase of growth, when the highest level of bacterial accumulation is reached, the intensity of metabolic processes decreases, there is an increase in cell resistance to freezing and drying (Vygovska et al., 2007; Vyigovskaya et al., 2008).

The choice of a protective suspension medium is important for effective lyophilization. Colloidal solutions are used for this purpose. The components of the suspension protective media, as a rule, introduce substances that reduce the crystallization point of water; this prolongs the cooling time of the cells and creates conditions for minimizing the negative effects of ice crystals, as well as in some way provides a protective effect during freeze-drying (Emtsova et al., 1991; Osadchaya et al., 2002; Akymenko, 2007; Romanko, 2010; Hordiienko et al., 2011; Romanko et al., 2012; Holovko et al., 2015; Hordiienko et al., 2018).

For bacteria, cryopreservation and subsequent freeze-drying under vacuum are stressors that affect the cell due to increased osmotic pressure, temperature shock, changes in intracellular pH, high salt concentration. They lead to the accumulation of non-lethal and lethal damage to the structures (cells) of the biological object (Osadchaya et al., 2002; Holovko et al., 2004; Romanko et al., 2006; Vygovska et al., 2007; Ushkalov et al., 2008; Hordiienko et al., 2011).

Non-lethal damage and the resulting changes in the properties of bacterial cultures are usually reversible and are restored to normal under appropriate conditions and with the use of certain methods. The rate and quality of the recovery of biological properties in lyophilized bacterial culture depend on the quality of culture media used for this purpose. Some authors recommend adding specific components to the culture media intended for the cultivation and recovery of certain microorganism species (Ushkalov et al., 2008; Kovtun et al., 2013; Holovko et al., 2015). The effectiveness of the used culture media determined by comparing the biological properties of bacterial cultures at the stage of laying for long-term storage, after lyophilization of the culture, and after its recovery in the appropriate culture medium (Postoienko et al., 2011; Hordiienko et al., 2011; Kovtun et al., 2013; Holovko et al., 2015).

Purpose. To investigate the effectiveness of culture media for the recovery of lyophilized pathogenic bacteria.

Materials and methods of research

The *Salmonella typhimurium*, *Pasteurella multocida*, *Yersinia pseudotuberculosis*, *Staphylococcus aureus* strains from the collection of Ukrainian Laboratory of Quality and Safety of Agricultural Products of the National University of Life and Environmental Sciences of Ukraine (ULQSAP of NUBiP) isolated during microbiological studies of pathological material from animals in the research department of ULQSAP of NUBiP of Ukraine, were used in the study.

Cultural and protective media were prepared and controlled in accordance with ISO 11133:2014 "Microbiology of food, animal feed and water. Preparation, production, storage and performance testing of culture media".

Faibich protective medium was used as a cryoprotectant (gelatin – 1.0%, sucrose – 10.0%, distilled water – 89%) in a ratio of 1:1 with the broth of 24-hour cultures of *Salmonella typhimurium*, *Pasteurella multocida,* and *Staphylococcus aureus*. Each test culture

was packaged 1.0 cm^3 into 5 cm^3 vials. Before lyophilization (cryopreservation and subsequent sublimation), three vials were taken from each experimental batch to determine the typicality, homogeneity, and concentration of bacterial mass in the suspension (CFU/cm^3). Cryopreservation of cultures was carried out in a freezer Forma 700 Series Thermo Scientific (USA) at -70 ºC.

Sublimation drying was performed in an LP-3 apparatus from TelStar (Spain) with a deep vacuum of 0.17 mB and a condenser temperature of 45–50 ºC. After lyophilization, the typicality, homogeneity, and concentration of viable microbial cells (CFU/cm^3) were determined in the experimental samples. In order to establish the concentration of viable microorganisms, samples were prepared in accordance with ISO 6887-1:2003 "Microbiology of food and animal feeding stuffs. Preparation of test samples, initial suspension and decimal dilutions for microbiological examination. Part 1. General rules for the preparation of the initial suspension and decimal dilutions".

The biological properties of the studied strains were determined before lyophilization and in cultures recovered on different nutrient media. The studies were performed according to ISO 6888-1:1999/ Amd 1:2003 "Microbiology of food and animal feeding stuffs – Horizontal method for the enumeration of coagulase-positive staphylococci (*Staphylococcus aureus* and other species) – Part 1: Technique using Baird-Parker agar medium; EN 12824:1997 • Standard Details • Microbiology of food and animal feeding stuffs – Horizontal method for the detection of Salmonella"; Metodychni rekomendatsii z diahnostyky, profilaktyky ta zakhodiv

1. Culture media for bacterial cultures

Strain	Nutrient media	Manufacturer
Salmonella typhimurium	Meat-peptone broth (MPB)	Pharmactive, Ukraine
	Brain-hearth infusion broth (BHIB)	HiMedia(India)
	Tryptone soya broth (TSB)	HiMedia (India)
Pasteurella multocida	MPB culture media with the addition of 5% equine serum and 0.5% glucose	Pharmactive, Ukraine
	MPB with the addition of 5% bovine serum and 0.5% glucose	Pharmactive, Ukraine
	Brain-hearth infusion broth	HiMedia (India)
	Tryptone soya broth	HiMedia (India)
Yersinia pseudotuberculosis	Meat-peptone broth	Pharmactive, Ukraine
	Brain-hearth infusion broth	HiMedia (India)
	Tryptone soya broth	HiMedia (India)
Staphylococcus aureus	MPB culture media with the addition of 5% equine serum and 0.5% glucose	Pharmactive, Ukraine
	MPB with the addition of 5% bovine serum and 0.5% glucose	Pharmactive, Ukraine
	Tryptone soya broth	HiMedia (India)
	Brain-hearth infusion broth	HiMedia (India)

borotby z pasterelozom (kholeroiu) ptytsi. (Stehnii et al., 2009); Metodicheskie ukazaniya «Epidemiologicheskiy nadzor i profilaktika psevdotuberkuleza i kishechnogo iersinioza» (2009).

In order to restore lyophilized bacterial cultures, several variants of culture media were used (Table 1).

Results of the research and their discussion

At the beginning of the experiment, the studied culture biological properties of the matrix broods of *Salmonella typhimurium*, *Pasteurella multocida*, *Yersinia pseudotuberculosis*, *Staphylococcus aureus* were determined (Table 2).

The studied cultures were characterized by population homogeneity and corresponding for each species typicality by morphological, cultural, and biochemical properties.

Culture of *S. typhimurium* on bismuth sulfite agar (BSA) medium (Pharmactive, Ukraine) formed black S-shaped colonies with a metallic luster, rounded, regular shape, 3–4 mm in diameter, the color of the medium around the colonies became black-gray. *S. typhimurium* fermented (with the formation of acid and gas) glucose, arabinose, mannitol, maltose, sorbitol, dulcite; reduced nitrates to nitrites, isolated H_2S. The culture of *S. typhimurium* was agglutinated with O-complex sera 1, 2 and monoreceptor H-agglutinating serum of the 1st phase and the 2nd phase – 1, 2, 5, 6.

Culture of *Y. pseudotuberculosis* on plate count agar medium (HiMedia, India) formed R-colonies at a temperature of 37 ºC, diameter 3–4 mm, large, irregularly shaped, with uneven edges, hilly, opaque, greenish-cream color, esculin, fermented glucose, α-arabinose, mannose, xylose, rhamnose, maltose, mannitol.

The culture of *P. multocida* on plate count agar medium (HiMedia, India) formed homogeneous S-colonies with a diameter of 0.7–1.2 mm, rounded, convex, shiny, with a smooth clear edge, milky white, translucent; fermented with the formation of acid without sugar: glucose, mannitol, sucrose.

2. Biological properties of the studied cultures (matrix cultivation)

Determined indicator (n = 5)	Salmonella typhimurium	Yersinia pseudotuberculosis	Pasteurella multocida	Staphylococcus aureus
Concentration of viable broth bacteria (MPB), CFU/cm^3	4.5×10^9	2.8×10^9	1.6×10^9	6.6×10^9
Concentration of viable cells (broth culture + protective medium, 1:1), CFU/cm^3	2.1×10^9	1.4×10^9	0.9×10^9	3.3×10^9
Typical growth on solid nutrient media	Typical of the species	Typical of the species	Typical of the species	Typical of the species
Homogeneity of the microorganism population	Homogeneous gram-negative rods in size 2–4 x 0.5–0.8 μm	Homogeneous gram-negative cocci and ovoids, 0.8–1.2 × 0.5–0.8 μm in size, mobile at 23 ºC, immobile at 37 ºC	Homogeneous small gram-negative ovoids, size 0.5–1 x 0.5–0.8 μm	Homogeneous gram-positive cocci, size 1.0–1 x 1.5–2.0 μm
Biochemical properties	Typical for the species	Typical for the species	Typical for the species	Typical for the species

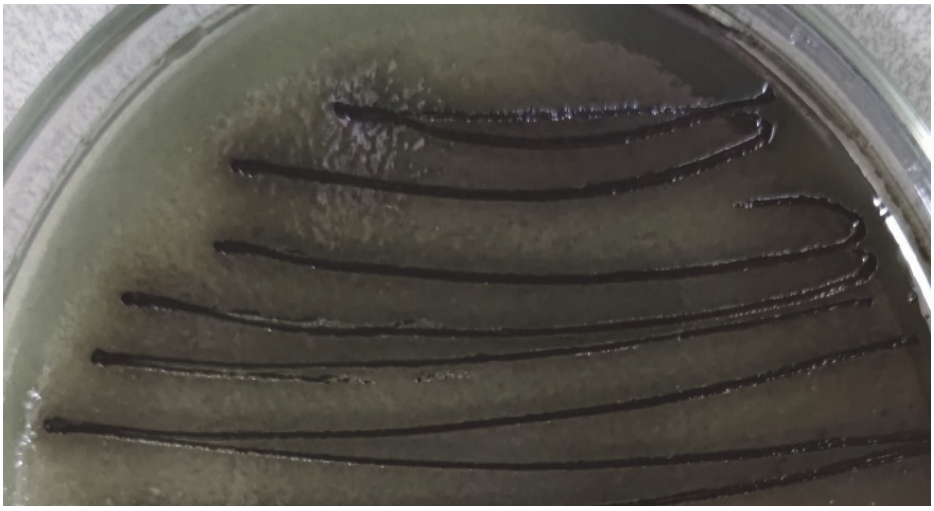

Fig. 1. Culture of S. typhimurium on bismuth sulfite agar (BSA) medium (Pharmactive, Ukraine)

Culture of *S. aureus* on Baird-Parker Agar medium (HiMedia, India) formed S-colonies, 1-2 mm in diameter, black, shiny, surrounded by a zone of enlightenment (lecithinase activity); coagulated rabbit plasma, fermented to form mannitol acid, glucose.

The studied cultures were lyophilized. Viability was determined in lyophilized cultures: population homogeneity, growth typicality on solid nutrient media and concentration of viable cells. The research results are shown in Table 3.

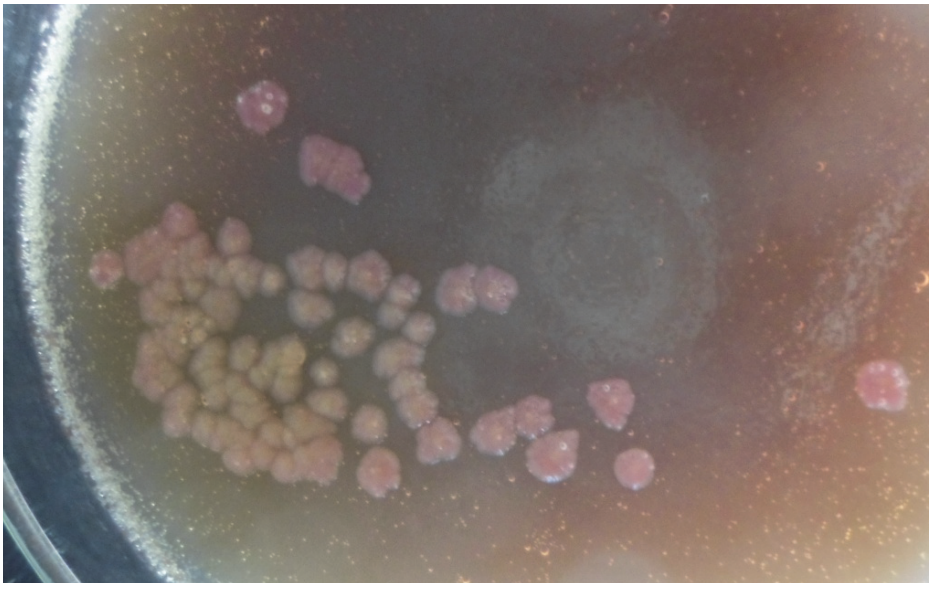

Fig. 2. Culture of Y. pseudotuberculosis R-colonies at a temperature of 37 ºC on Yersinia isolation agar (HiMedia, India)

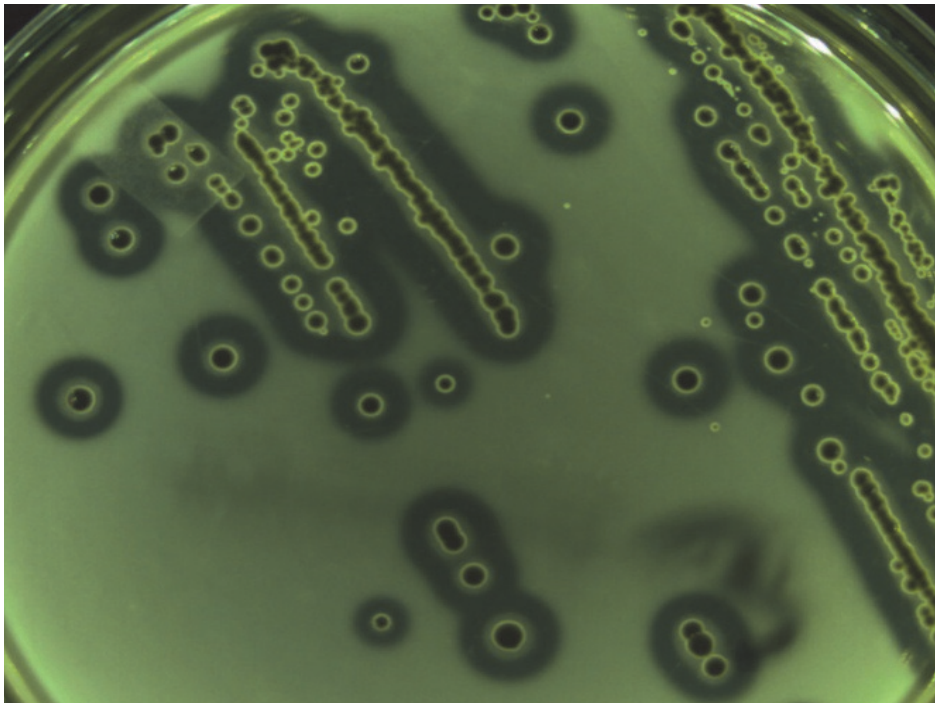

Fig. 3. Culture of S. aureus on Baird-Parker agar medium (HiMedia, India)

It was found that cultures subjected to lyophilization had a changed morphology: in smears of rehydrated lyophilizates of *S. typhimurium*, *Y. pseudotuberculosis*, *P. multocida* cultures recorded small polymorphic gram-negative structures: ovoids, rods; in smears of *S. aureus* – small gram-positive cocci, ovoids. On solid nutrient media after the appropriate incubation period, the rehydrated cultures formed colonies typical for the respective species of microorganisms. There was a significant decrease in the concentration of viable microbial cells in cultures after lyophilization. Thus, the concentration of viable microbes in

3. Viability of lyophilized cultures

Determined indicator (n = 5)	Salmonella typhimurium	Yersinia pseudotuberculosis	Pasteurella multocida	Salmonella typhimurium
Concentration of viable cells after lyophilization, CFU/cm^3	1.9×10^5	1.8×10^4	1.4×10^4	1.7×10^6
Homogeneity of the microorganism population	Small polymorphic gram-negative structures: ovoids, rods	Small polymorphic gram-negative structures: ovoids, rods	Small polymorphic gram-negative structures: ovoids, rods	Small gram-positive cocci, ovoids
Typical growth on solid nutrient media	Typical for the species	Typical for the species	Typical for the species	Typical for the species

cells of a lyophilized culture of *P. multocida* was 1.4×10^4 CFU/cm^3, *Y. pseudotuberculosis* – 1.8×10^4 CFU/cm^3, *S. typhimurium* 1.9×10^5 CFU/cm^3, *S. aureus* – 1.7×10^6 CFU/cm^3, which is from baseline 0.09%, 0.013%, 0.016%, and 0.05%, respectively. Rehydrated cultures were inoculated into appropriate culture media (Table 4). After the appropriate incubation period in the studied cultures, the homogeneity of the population of microorganisms and the concentration of viable cells were determined. From daily broth cultures made sowings on the corresponding solid nutrient media. After the appropriate incubation period, the typical growth of inoculated cultures was determined. The studied populations of cultures had homogeneous cell morphology, during incubation on solid nutrient media formed typically for the species colonies. The results of determining the concentration of viable cells in microorganism populations on different culture media are shown in Table 4.

The obtained results indicate that the biomass of the studied cultures in the initial titer $x \times 10^9$ was obtained by a single passage on different culture media. The highest productivity in recovered cultures was obtained with the use of BHIB, (HiMedia, India) (the concentration of live microbial cells in the experimental cultures was recorded in the range of $5.7–6.4 \times 10^9$ CFU/cm^3). The productivity of *S. typhimurium* culture with the use of MPB and TSB was

4. Concentration of viable cells in recovered cultures

Culture media	Concentration of viable cells, CFU/cm^3
Salmonella typhimurium	
Meat-peptone broth	2.1×10^9
Brain-hearth infusion broth	6.0×10^9
Tryptone soya broth	2.6×10^9
Yersinia pseudotuberculosis	
Meat-peptone broth	1.8×10^9
Brain-hearth infusion broth	5.7×10^9
Tryptone soya broth	2.1×10^9
Pasteurella multocida	
MPB culture media with the addition of 5% equine serum and 0.5% glucose	1.5×10^9
MPB with the addition of 5% bovine serum and 0.5% glucose	1.1×10^9
Brain-hearth infusion broth	6.1×10^9
Tryptone soya broth	1.0×10^9
Staphylococcus aureus	
MPB culture media with the addition of 5% equine serum and 0.5% glucose	2.3×10^9
MPB with the addition of 5% bovine serum and 0.5% glucose	2.0×10^9
Brain-hearth infusion broth	6.4×10^9
Tryptone soya broth	4.1×10^9

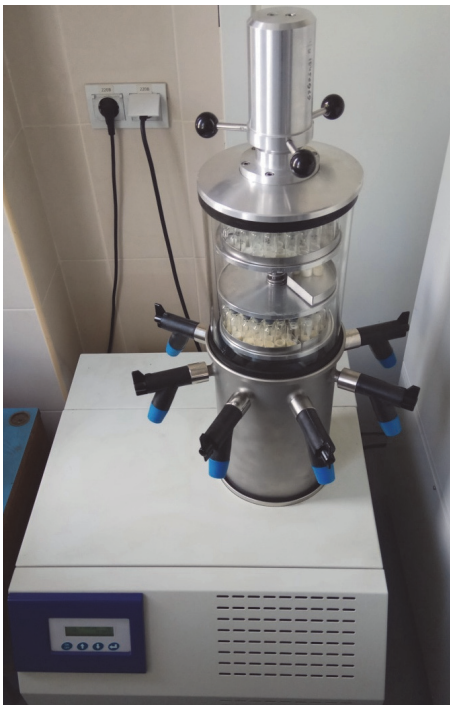

Fig. 4. The process of lyophilization

lower by 65 and 57%, respectively. The productivity of *Y. pseudotuberculosis* culture with the use of BHIB and TSB was lower by 68 and 63%, respectively. The productivity of *P. multocida* culture with the use of MPB with 5% equine serum and 0.5% glucose, MPB with 5% bovine serum and 0.5% glucose and TSB was lower by 75%, 82, and 84%, respectively. The productivity of *S. aureus* culture with the use of MPB with 5% equine serum and 0.5% glucose, MPB with 5% bovine serum and 0.5% glucose, TSB was lower by 64%, 69, and 36% respectively.

Conclusion and future perspectives

1. It was found that in the process of sublimation and cryopreservation of *Salmonella typhimurium*, *Pasteurella multocida*, *Yersinia pseudotuberculosis*, *Staphylococcus aureus* cultures, the loss of viable microbial cells was 99.91–99.987%.
2. The concentration of viable microbial cells in lyophilized cultures of *Salmonella typhimurium*, *Pasteurella multocida*, *Yersinia pseudotuberculosis*, *Staphylococcus aureus* was recorded in the range of 1.4×10^4–1.7×10^6 CFU/cm^3.
3. During a single passage on different culture media, the biomass of the studied cultures was obtained in the initial titer $x \times 10^9$.
4. The highest productivity in recovered brain-hearth infusion broth manufactured by HiMedia, India (concentration of live microbial cells in experimental cultures was recorded in the range of 5.7–6.4×10^9 CFU/cm^3).

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Анотація. *На сьогодні найбільш доцільним способом довготривалого зберігання більшості штамів мікроорганізмів у колекціях є їх ліофілізація. Швидкість та якість відновлення біологічних властивостей ліофілізованих бактеріальних культур багато залежить від якості культуральних середовищ, що використовують з цією метою. Метою було дослідити ефективність культуральних середовищ для відновлення ліофілізованих патогенних бактерій.*

У роботі використовували штами Salmonella typhimurium, Pasteurella multocida, Yersinia pseudotuberculosis, Staphylococcus aureus з колекції Української лабораторії якості і безпеки продукції АПК Національного університету біоресурсів і природокористування України. Для відновлення ліофілізованих бактеріальних культур використовували декілька варіантів культуральних середовищ: м›ясо-пептонний бульйон (Фармактив, Україна) з додаванням 5% сироватки крові коня та 0,5% глюкози; м›ясо-пептонний бульйон (Фармактив, Україна) з додаванням 5% сироватки крові великої рогатої худоби та 0,5 % глюкози; серцево-мозковий бульйон (HiMedia, India) та триптон-соєвий бульйон (HiMedia, India). В якості кріопротектора використовували захисне середовище Файбича. Встановлено, що в процесі сублімації та кріоконсервації культур Salmonella typhimurium, Pasteurella multocida, Yersinia pseudotuberculosis, Staphylococcus aureus втрати життєздатних мікробних клітин становили 99,91–99,98%. Концентрацію життєздатних мікробних клітин у ліофілізованих культур Salmonella typhimurium, Pasteurella multocida, Yersinia pseudotuberculosis, Staphylococcus aureus реєстрували в межах $1,4\times10^4$–$1,7\times10^6$ КУО/см^3. За однократного пасажування на різних культуральних середовищах було отримано біомаси досліджуваних культур у вихідному титрі $x \times 10^9$. Найвищу продуктивність у відновлених культур біло отримано за застосування серцево-мозкового бульйону виробництва компанії HiMedia, India (концентрацію живих мікробних клітин у дослідних культур реєстрували в межах $5,7$–$6,4 \times 10^9$ КУО/см^3).

Ключові слова: *Salmonella, Pasteurella, Yersinia, Staphylococcus, поживні середовища, ліофілізація*

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CORTICAL MECHANISMS OF REGULATION OF LITHIUM CONTENT IN BLOOD OF COWS DEPENDING ON THE SEASONS

O. V. ZHURENKO, *Doctor of Veterinary Sciences,*
Department of Animal Biochemistry and Physiology
named after Academician M. F. Gulyi
https://orcid.org/0000-0002-4933-0372
V. I. KARPOVSKYI, *Doctor of Veterinary Sciences, Professor,*
Department of Animal Biochemistry and Physiology
named after Academician M. F. Gulyi
https://orcid.org/0000-0003-3858-0111
V. V. ZHURENKO, *Candidate of Veterinary Sciences,*
Department of Animal Biochemistry and Physiology
named after Academician M. F. Gulyi
https://orcid.org/ 0000-0003-2097-9212
National University of Life and Environmental Sciences of Ukraine, Kyiv, Ukraine
E-mail: Zhurenko-lena@ukr.net

Abstract. *The behavior of farm animals, especially cattle, is an important economic and useful feature, which significantly facilitates the operating conditions and production of livestock products. The parameters of the nervous system in cattle determine its behavior in various situations, including keeping in the pen, herding, and milking. The optimal content of minerals in the body leads to the normal course of metabolic processes and high productivity. Based on the results of studying the conditioned reflex activity, four experimental groups were formed. Whole blood, serum, and blood cells were used for laboratory analysis. Based on the results of the analysis of variance of the lithium content in different blood fractions of cows, no reliable interaction between the typological features of the nervous system and the season has been established. The mobility of nervous processes, regardless of the season, is reliably associated with the lithium content in whole blood, blood cells, and blood serum (r = 0.15–0.22). Along with this, the parameter of the lithium transmembrane potential (Licell/Liserum) is reliably associated mainly with the strength and balance of nervous processes in cows in the warm season – r = 0.62–0.76 (P < 0.05–0.01). A significant dependence on the type of higher nervous activity in cows and the lithium content in blood serum (F = 13.2 > FU = 3.01; P < 0.001), whole blood (F = 14.8 > FU = 3.01; P < 0.001), and blood cells (F = 23.1 > FU = 3.01; P < 0.001) is established. In cows with a weak type of higher nervous activity, the lithium content in blood serum and its cells was lower by 12.1% (P < 0.05) and 18.0% (P < 0.05), respectively, compared with the parameters of cows with a strong balanced mobile type.*

Keywords: *higher nervous activity, micronutrients, types of higher nervous activity, nervous processes*

Introduction

Over the past decades, there have been fundamental changes in the field of world veterinary medicine, which make it possible to assert that without the application of advances in biochemistry, physiology, microbiology, and other disciplines, it is impossible to fully realize the productive and breeding qualities of animals. Microbiological, biochemical, and physiological processes in the body of animals determine the entire course of individual development in animals, its existence, and the productivity development (Avtsyn et al., 1991). The behavior of farm animals, especially cattle, is an important economically useful feature, which significantly facilitates the operating conditions and production of livestock products (Gapon & Yashchenko, 2005). The parameters of the nervous system in cattle determine its behavior in various situations, including keeping in the pen, herding, and milking. The use of knowledge in technology on the temperament of animals, the type of their higher nervous activity, and the state of the autonomic nervous system due to both heredity and environmental impact, creates the preconditions for the full realization of its genetic potential.

Analysis of recent researches and publications

The type of higher nervous activity in animals determines not only the nature of the adaptive reactions in the organism but also the main characteristics of cortical processes affecting various metabolism levels, which is reflected in the economically useful properties of productive animals (McDowell, 2003). The optimal mineral content in the body leads to the normal course of metabolic processes and high productivity (Hrushanska et al., 2017). The value of mineral nutrition in cattle depends on animal's provision with essential micronutrients that are part in the structure of many enzymes or are their activators, taking a leading role in redox reactions (Guyot et al., 2012). However, insufficient attention is paid to the studying of individual features of mineral homeostasis in the body of productive cows in intact and stressful state (McDowell, 2003; Zinko, 2017). The determination of the individual features of higher nervous activity in animals allows understanding deeper the cortical mechanisms of regulation of various physiological functions, creating the preconditions for targeted exposure (Pogorlov, 2010; Danchuk et al., 2017). Micronutrients play a significant biological role despite their low content in the body (Byts, 2010; Gromova et al., 2010). In addition to the general positive effect on the growth and development processes, the specific effect of several micronutrients on the most important physiological processes has been established, and their importance is explained by the fact that they come into a close relationship with biologically active substances – hormones and vitamins (Zakharenko, 2004). Lithium is a very valuable and important micronutrient for animals. This element affects the serotonin release and receptor sensitivity, as well as modulates the norepinephrine action (Skalny, 2004; Kalyn, 2011). Today it is believed that the mechanism of lithium action is associated with the depletion of inositol reserves in the central nervous system (Marushko, 2013). It is known from literature sources that lithium has the ability to reduce the excitability of the central nervous system by releasing magnesium from cellular "depots" and inhibiting the transmission of nerve impulses; regulate sodium transport in nerve and muscle cells.

Materials and methods of research

The experiments were carried out on cows of the Ukrainian black-and-white dairy breed of the 2–3rd lactation. The types of higher nervous activity were determined by the express method for assessing conditioned reflex activity in cattle, which allows reliably assert that the animal belongs to the corresponding type of higher nervous activity in 20–30 minutes of the experiment. The conditions of use, keeping, diet, and feeding frequency were the same in all experimental animals. To study the conditioned reflex activity, 100 cows were selected. The strength, balance, and mobility of the nervous processes were determined in all animals using a modified method. The method is based on the observance of the behavior in an animal in a group and individual pen, the reaction of the animal to the experimenter, the reaction of a hungry animal to feeding, unexpected sensory stimuli, and the formation of conditioned reflexes.

The typological characteristics of the nervous system were determined by three tests analysis.

According to the results of studying the conditioned reflex activity, 4 experimental groups were formed. The first group included animals with a strong balanced mobile type, the second – a strong balanced inert type, the third – a strong unbalanced type, and the fourth – a weak type of higher nervous activity. Blood from cattle was obtained from the jugular vein. During blood sampling, the unnecessary abuse of the animal was avoided. Whole blood, serum, plasma, and blood cells were used for laboratory analysis. Blood from animals was collected in three test tubes. The first test tube contained the whole blood, the second was used to extract blood serum for analysis, and the third one – to obtain plasma and blood cells. To stabilize whole blood and to obtain plasma, three drops of 1% heparin solution were preliminarily introduced into the test tube. To obtain plasma, blood with the anticoagulant immediately after its collection was centrifuged at 2000–3000 rpm for 15–20 min, after which the plasma was poured into another tube. To obtain blood cells, the cell pellet was washed out three times in cold saline solution, followed by centrifugation at 3000 rpm for 15 min. To obtain blood serum, no anticoagulant was added. After blood sampling, the tube was left at room temperature until the serum was completely separated, after which manipulations were performed to obtain the serum following standard procedures. After preparing the samples, they were immediately sent to the laboratory in a cooler bag (Vlizlo et al., 2012).

To determine micro- and macronutrients, the samples are preliminarily mineralized by the method of dry or wet ashing. After ashing, acid extraction is carried out. In prepared samples, the elements are determined by atomic absorption spectrophotometry. Experimental research is consistent with the basic principles of the European Convention for the Protection of Vertebrate Animals used for Experimental and other Scientific Purposes (Strasbourg, 1986) and the Declaration on the Humane Treatment of Animals (Helsinki, 2000). The obtained digital data were processed statistically using the applied software package "Microsoft Office Excel 2013". The arithmetic mean value (M) and its error (m) were determined. The probability of differences in mean values was determined by the Student's test. Parameters changes were considered significant at $P < 0.05$ (including $P < 0.01$ and $P < 0.001$). In

addition, correlation, regression, one and two-factor analysis of variance of the obtained results were carried out.

Results of the research and their discussion

Studies have shown that in animals with different types of higher nervous activity, the lithium content in blood serum, whole blood, and its cells did not exceed physiological limits and was 0.42–0.52 μg/100 ml, 0.33–0.42 μg/100 ml, and 0.18–0.23 μg/100 ml, respectively (Table 1).

There were no significant differences in the lithium content in different blood fractions in cows with strong balanced mobile and strong balanced inert type of higher nervous activity in different seasons of the year. Also, the lithium content in different blood fractions in cows with different types of higher nervous activity in cold and warm seasons did not differ significantly.

In summer, in cows with a strong unbalanced type of higher nervous activity, the lithium content was lower by 15.7% ($P < 0.01$), 17.5% ($P < 0.05$), and 19.1% ($P < 0.01$) in serum, whole blood, and its cells, respectively, than in animals with a strong balanced mobile type. Whereas in winter, the lithium content in the blood serum, whole blood, and blood cells in cows of this type of higher nervous activity was lower by 8.9–11.6 ($P < 0.05$–0.01), respectively, compared with the indicators in cows with a strong balanced mobile type.

In summer, cows with a weak type of higher nervous activity had lower lithium content in blood serum and its cells by 12.1% ($P < 0.05$) and 18.0% ($P < 0.05$), respectively, compared with the indicators of cows with a strong balanced mobile type. Whereas in winter, the lithium content in blood serum, whole blood, and blood cells in cows of this type of higher nervous activity was lower by 14.6–16.3% ($P < 0.05$–0.01), respectively, compared with the indicators of cows with a strong balanced mobile type.

1. Lithium content in the blood of cows with different types of higher nervous activity depending on the season (μg/100 ml; M ± m, n = 5)

Substrate	Type of higher nervous activity			
	Strong balanced mobile	Strong balanced inert	Strong unbalanced	Weak
Summer				
Blood serum	0.495 ± 0.016	0.523 ± 0.015	0.418 ± 0.011**	0.435 ± 0.034*
Whole blood	0.400 ± 0.011	0.421 ± 0.014	0.330 ± 0.010*	0.345 ± 0.027
Blood cells	0.223 ± 0.006	0.230 ± 0.007	0.180 ± 0.004**	0.183 ± 0.012*
Licell/Liserum	0.450 ± 0.003	0.440 ± 0.009	0.431 ± 0.004*	0.421 ± 0.008*
Winter				
Serum	0.488 ± 0.009	0.510 ± 0.009	0.443 ± 0.009*	0.415 ± 0.022*
Whole blood	0.393 ± 0.006	0.413 ± 0.009	0.358 ± 0.006*	0.335 ± 0.017*
Blood cells	0.215 ± 0.003	0.225 ± 0.006	0.19 ± 0.004**	0.180 ± 0.008**
Licell/Liserum	0.441 ± 0.007	0.441 ± 0.005	0.430 ± 0.015	0.435 ± 0.010

Note: significant differences compared to cows with a strong balanced mobile type of higher nervous activity at * $P < 0.05$, ** $P < 0.01$.

2. Correlation (r) of the lithium content in blood of cows with the main characteristics of nervous processes (CU, n = 16)

Indicator Strength		The main characteristics of nervous processes		
		Balance	Mobility	
Blood serum	Summer	0.28	0.66**	0.17
	Winter	0.28	0.68**	0.21
Whole blood	Summer	0.39	0.81***	0.22
	Winter	0.45	0.70**	0.21
Blood cells	Summer	0.63**	0.69**	0.20
	Winter	0.65**	0.71**	0.15
Licell/Liserum	Summer	0.62*	0.76***	0.10
	Winter	0.08	0.30	-0.22

Note: indicators are significant at * P < 0.05,** P < 0.01, *** P < 0.001.

The ratio of the lithium content in blood cells to the blood serum (Li_{cell}/Li_{serum}) in cows with different types of higher nervous activity was 0.42–0.45 CU. It should be noted that this indicator in the blood of cows with different types of higher nervous activity in the cold season did not differ significantly, however, in summer, in cows with strong unbalanced and weak type of higher nervous activity it was lower by 4.1% (P < 0.05) and 6.4 % (P < 0.05), respectively.

The relationship between the main characteristics of nervous processes in cows and the lithium content in blood depending on the season has been established (Table 2).

The strength of nervous processes is directly related to the lithium content only in blood cells in summer (r = 0.63; P < 0.01) and in winter (r = 0.65; P < 0.01). Instead, the balance of nervous processes, depending on the season, is directly related to the lithium content in blood serum – r = 0.66–0.68 (P < 0.05), whole blood – r = 0.70–0.81 (P < 0.01–0.001), and blood cells – r = 0.69–0.71 (P < 0.01). The mobility of nervous processes, regardless of the season, is significantly associated with the lithium content in whole blood, blood cells, and blood serum (r = 0.15–0.22). Along with this, the indicator of the transmembrane potential of lithium (Li_{cell}/Li_{serum}) is significantly associated with the strength and balance of nervous processes in cows in the warm season – r = 0.62–0.76 (P < 0.05–0.01). The strength of nervous processes in the warm season does not significantly limit the lithium content in blood (η^2_χ = 0.11–0.22), however, it significantly affects the ratio of the lithium content in blood cells and serum –η^2_χ = 0.30 (P < 0.05). Whereas in the cold season, the strength of nervous processes increases the effect on the lithium content in whole blood, serum, and blood cells to a significant level – η^2_χ = 0.39–0.42 (P < 0.001). However, the existing influence of the strength of nervous processes on the ratio of lithium in the blood cells and serum in cows becomes insignificant (η^2_χ = 0.04).

The balance of nervous processes in cows in summer significantly affects the lithium content in blood serum – η^2_χ = 0.54 (P < 0.001), whole blood – η^2_χ = 0.58 (P < 0.001), and blood cells – η^2_χ = 0.73 (P < 0.001). In winter, the balance of nervous processes retains a

3. Regression analysis of the dependence of the lithium content in blood of cows on the main characteristics of nervous processes (CU; n = 16)

Indicator	The main characteristics of nervous processes					
	Strength		Balance		Mobility	
	Summer	Winter	Summer	Winter	Summer	Winter
Blood serum						
Regression coefficient	0.019	0.033**	0.041**	0.034**	0.011	0.01
Coefficient of determination	0.08	0.39**	0.43**	0.48**	0.03	0.04
Whole blood						
Regression coefficient	0.016	0.028**	0.036**	0.027**	0.011	0.006
Coefficient of determination	0.08	0.42**	0.47**	0.5**	0.04	0.02
Blood cells						
Regression coefficient	0.012	0.015*	0.024***	0.018***	0.007	0.002
Coefficient of determination	0.15	0.38*	0.65***	0.58**	0.05	0.01
Licell/Liserum						
Regression coefficient	0.008	0.002	0.012**	0.006	0.004	-0.004
Coefficient of determination	0.2	0.01	0.49**	0.09	0.05	0.05

Note: indicators are significant at * $P < 0.05$,** $P < 0.01$, *** $P < 0.001$.

significant effect on the lithium content in the blood of cows up to the $\eta^2_\chi = 0.64–0.71$ ($P < 0.001$). The mobility of nervous processes does not significantly affect the lithium content in serum, whole blood, and cells of cows regardless of the season ($\eta^2_\chi = 0.08–0.17$).

It should be noted that the ratio of lithium content in cells and blood serum in summer is significantly limited by the strength, balance, and mobility of nervous processes – $\eta^2_\chi = 0.27–0.37$ ($P < 0.05$), while in winter this effect becomes insignificant ($\eta^2_\chi = 0.02–0.06$).

Regression analysis established the dependence of the lithium content on the mobility of nervous processes in cows (Table 3).

On the other hand, regardless of the season, when the balance of nervous processes changes by one unit, the lithium content in whole blood, blood cells, and its serum changes in the same way by 0.02–0.04 μg/100 ml ($P < 0.01–0.001$). The coefficient of determination of the strength of nervous processes with the content of this micronutrient indicates that 43–65% ($P < 0.01–0.001$) of variations in its content in different blood fractions are due to the variability of indicators of nervous process balance.

Unlike it, only in winter, when the strength of the nervous processes changes by one unit, the lithium content in different blood fractions changes in the same way by 0.02–0.03 mg/100 ml ($P < 0.001$). In cows' blood cells in winter 38–42% ($P < 0.001$) of variations in the content of this element are due to the variability of indicators of nervous process strength.

In addition, it was found that in summer only 49% ($P < 0.01$) of variations in the ratio of the lithium content in blood serum to blood cells in cows might be caused by the balance of nervous processes. Therefore, when the indicator of

4. Multivariate analysis of variance of the influence of higher nervous activity type and the season on the lithium content in blood of cows

Source of variation	SS	df	MS	F	P-value	F-test
Blood serum						
Higher nervous activity type	0.0491	3	0.0164	13.2	< 0.001	3.01
Season	0.0001	1	0.0001	0.09	0.766	4.26
Correlation	0.0024	3	0.0008	0.63	0.600	3.01
Internal	0.0298	24	0.0012			
Total	0.0814	31				
Whole blood						
Higher nervous activity type	0.0348	3	0.0116	14.8	< 0.001	3.01
Season	< 0.001	1	< 0.001	0.003	0.952	4.26
Correlation	0.0019	3	0.0006	0.822	0.495	3.01
Internal	0.0188	24	0.0008			
Total	0.0556	31				
Blood cells						
Higher nervous activity type	0.0132	3	0.0044	23.1	< 0.001	3.01
Season	< 0.001	1	< 0.001	0.066	0.799	4,26
Correlation	0.0004	3	0.0001	0.637	0.598	3.01
Internal	0.0046	24	0.0002			
Total	0.0181	31				

nervous processes balance changes by one unit, the ratio of the lithium content in blood serum to blood cells changes in the same way by 0.012 CU ($P < 0.01$).

The results of the multivariate analysis of variance of the influence of the higher nervous activity type and the season on the lithium content in blood of cows are shown in Table 4.

A significant dependence between the type of higher nervous activity in cows and the lithium content in blood serum ($F = 13.2 > FU = 3.01$; $P < 0.001$), whole blood ($F = 14.8 > FU = 3.01$; $P < 0.001$), and blood cells ($F = 23.1 > FU = 3.01$; $P < 0.001$) was found. The season, in contrast to the type of nervous system in cows, does not have a significant effect on the lithium content in different blood fractions.

Based on the results of the analysis of variance of the lithium content in different blood fractions in cows, no significant interaction between the typological features of the nervous system and the season has been established.

Conclusions and future perspectives

A significant dependence between the cows' type of higher nervous activity and the lithium content in blood serum ($F = 13.2 > FU = 3.01$; $P < 0.001$), whole blood ($F = 14.8 > FU = 3.01$; $P < 0.001$), and blood cells ($F = 23.1 > FU = 3.01$; $P < 0.001$) has been established. In cows with a weak type of higher nervous activity, the lithium content in blood serum and its cells was lower by 12.1%

($P < 0.05$) and 18.0% ($P < 0.05$), respectively, as compared with the indicators in cows with a strong balanced mobile type. Prospects for further research consist in the development of modern tools and methods for correcting the content of macro- and micronutrients in cows' blood, considering the individual characteristics of their nervous system.

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Анотація. *Поведінка сільськогосподарських тварин, а особливо великої рогатої худоби, є важливою господарсько-корисною ознакою, що значно полегшує умови експлуатації та виробництва продукції тваринництва. Параметри нервової системи великої рогатої худоби визначають її поведінку в різних ситуаціях, зокрема, в загоні, вигулі, під час доїння. Оптимальний вміст мінеральних речовин в організмі зумовлює нормальний перебіг процесів метаболізму і високу продуктивність. За результатами дослідження умовно-рефлекторної діяльності було сформовано чотири дослідні групи. Для лабораторного аналізу використовували цільну кров, сироватку, плазму та клітини крові. За результатами дисперсійного аналізу вмісту Літію в різних фракціях крові корів вірогідну взаємодію між типологічними особливостями нервової системи та порою року не встановлено. Рухливість нервових процесів незалежно від пори року вірогідно пов'язана з вмістом Літію в цільній крові, клітинах крові та сироватці крові (r = 0,15–0,22). Водночас показник трансмембранного потенціалу за Літієм (Ліклітин/ Ліcироватки) вірогідно пов›язаний лише із силою та врівноваженістю нервових процесів у корів у теплу пору року – r = 0,62–0,76 (P < 0,05–0,01).*

Встановлено вірогідну залежність від типу вищої нервової діяльності корів та вмісту Літію в сироватці крові (F = 13,2 > FU = 3,01; P < 0,001), цільній крові (F = 14,8 > FU = 3,01; P < 0,001) та клітинах крові корів (F= 23,1 > FU = 3,01; P < 0,001). У корів зі слабким типом ВНД вміст Літію в сироватці крові та її клітинах був меншим відповідно на 12,1% (P < 0,05) та 18,0 % (P < 0,05) порівняно до показників корів із сильним врівноваженим рухливим типом.

Ключові слова: *вища нервова діяльність, макроелементи, типи вищої нервової діяльності*

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INFUSION THERAPY IN THE PERIOPERATIVE PERIOD IN DOGS AND CATS

P. K. SOLONIN, *Candidate of Veterinary Sciences, Associate Professor,*
Department of Surgery and Pathophysiology
named after Academician I. O. Povazhenko
https://orcid.org/0000-0003-0119-6490
National University of Life and Environmental Sciences of Ukraine, Kyiv, Ukraine
M. A. KULIDA, *Candidate of Veterinary Sciences, Associate Professor,*
Department of Surgery and Pathophysiology
named after Academician I. O. Povazhenko
https://orcid.org/0000-0001-8937-1972
National University of Life and Environmental Sciences of Ukraine, Kyiv, Ukraine
E-mail: mkulida@ukr.net

Abstract.*The modern approach to the treatment of animals with surgical pathology requires the application of infusion solutions throughout the whole perioperative period: before the surgery (in case of emergency treatment), during the surgery, and after it.*

In animals with surgical diseases that come for treatment, there are quite often varying degrees of water-electrolyte balance disorder. The cause of these disorders is both surgical pathology itself (for example, peritonitis, bowel obstruction), and concomitant pathology present in the patient (renal failure, diabetes mellitus, cardiac deficiencies, etc.). The success of surgery treatment largely depends on the proper assessment and correction of these disorders.

This article presents modern approaches to the issues on infusion therapy in veterinary surgery of dogs and cats.

Great attention is paid to the selection of means for infusion therapy in animals in the perioperative period. The article contains examples of determining the volume of solutions for infusion during the preoperative preparation, intensive therapy for massive intraoperative blood loss, and postoperative management of patients.

Keywords: *perioperative period, infusion therapy, blood loss, crystalloids, colloids, infusion solutions*

Introduction

The modern approach to the treatment of animals with surgical pathology requires the application of infusion solutions throughout the perioperative period: before surgery (in case of acute interventions), during surgery, and after surgery (Battaglia & Steele, 2021).

In animals with surgical diseases that come for treatment, a varying degree of water-electrolyte balance (WEB) disorder is often observed. The cause of these disorders is both surgical pathology itself (for example, peritonitis, bowel obstruction), and concomitant pathology present in the patient (renal failure, diabetes mellitus, cardiac deficiencies, etc.). The success of the surgical treatment depends on the proper assessment and correction of these disorders (Belyayev et al., 2004).

The ***purpose*** of the study was to investigate modern approaches to the issues on infusion therapy in veterinary surgery of dogs and cats.

Materials and methods of research

The material of the research was modern publications that describe the issues of infusion therapy in veterinary surgery of dogs and cats, which is very important in the practical training of veterinary medicine practitioners. The methodological basis of the study is an investigative approach, dialectically combined with the principles of systematicity. Chronological, systematic, and analytical methods were used in the research process.

Results of the research and their discussion

Preoperative infusion therapy.

The scope and tasks of preoperative infusion preparation depend on many factors and often differ significantly in preparation for planned and urgent surgery.

Planned surgical interventions. When preparing the animals for planned surgical treatment, it is necessary first of all to compensate for the existing violations of hemoconcentration indices. Thus, it is recommended in most clinical cases that before the planned surgery, the hemoglobin level should be within the range of 110–180 g/L for dogs and 80–150 g/L for cats, hematocrit level – at least 37% for dogs and 26% for cats, and albumin level – at least 25 g/L for dogs and cats. Maintenance of such indicators creates optimal conditions for healing of postoperative wounds, recovery of functions, as well as protection against the development of dangerous anemia as a result of possible development of intraoperative blood loss (Cherniy et al., 2012).

Three variants of infusion therapy are possible in preparation for planned surgery depending on the patient's category:

The first category of patients – healthy or sick animals that do not require infusion therapy. This applies to patients who do not have significant health impairments, which are planned for surgical procedures with small duration and injures (castrations, amputations of stubby fingers, extractions of milk teeth). As a rule, these patients do not have signs of dehydration and WEB disorders, and after the surgery, they quickly start taking water. Thus, WEB disorders do not develop in these animals, and, therefore, infusion therapy in the perioperative period is not required;

The second category of patients – animals with chronic disorders of water-electrolyte metabolism that require appropriate treatment. Most often these disorders are caused by a deficiency of one or several ions. For example, the hypokalemic and hypochloremic alkalosis is formed during pyloroduodenal steno-

sis, which requires clear determination of potassium and chlorine deficiency and its appropriate correction (Table 1);

The third category of patients – those who develop severe WEB disorders before the planned surgery or are first diagnosed with a new concomitant disease during the examination, at which dangerous WEB disorders are possible. Examples of such disorders can be firstly detected signs of cardiovascular deficiency, renal deficiency, and diabetes mellitus (Butrov & Galenko, 2008; Ko, 2019).

In a large number of cases, latent diseases are detected accidentally during the screening examination of patients before surgical treatment. In this case, it is recommended to postpone planned operative treatment for further follow-up examination of the patient, to ensure compensation for the detected disease and to determine the risk degree (Shlapak et al., 2013).

Urgent surgical interventions. Most often these interventions are performed due to urgent surgeries on abdominal cavity organs, traumas. Infusion therapy in these situations should be focused on the support of adequate hemodynamics, preloading, and cardiac output (Detyu, 2009).

It should be remembered that preoperative preparation significantly reduces the risk of complications and mortality in sick animals with signs of "acute abdomen". The disadvantages of infusion therapy in such patients may not have a significant effect on the course of the surgery itself but will certainly be fully manifested after it. The consequences of poor preoperative infusion preparation in such patients are varying degrees of damage to the kidneys, lungs, liver, which might be completely avoided (Galushko, 2011).

The modern standards for preoperative preparation of sick animals with urgent surgical pathology include the following actions:

- catheterization of two veins;
- catheterization of the urinary bladder;
- infusion therapy with crystalloid and colloidal solutions in the appropriate volumes.

It is important to note that infusion preparation of the patient for surgery should be started with the introduction of crystalloids. Under no circumstances can infusion therapy be started with the introduction of colloids. First of all, it is necessary to carry out the rehydration of the body. If the sick animal has water deficiency – it should first of all be given water, i.e. crystalloidal solutions. If you start the infusion of colloids, the patient is

1. Pathologic conditions, losses of electrolytes and their replenishment (Hilberi, 1989)

Condition	Losses	Replenishment
Gastric vomiting	K^+, H^+, Cl^-, Na^+, H_2O	Sol. 0.9% NaCl + KCl 10–20 mmol/L
Duodenal vomiting	Mixed losses	Hartmann's solution
Diarrea	Na^+, Cl^-, HCO_3^-, K^+, H_2O	Hartmann's solution + soda 2–3 mmol/L + KCl 10–20 mmol/L
Bowel obstruction	Mixed losses of a severe degree	Hartmann's solution + plasma to relieve hypovolemic shock
Unclear etiology (in case of unaccounted losses)	Unknown	Multicomponent salt solutions (Normofundin + 5% glucose)
Uremia (rupture of the bladder)	Accumulation of metabolic waste products, K^+, H^+	Sol. 0.9% NaCl or Normofundin + 5% glucose + soda 2–3 mmol/kg

highly likely to develop side effects. Thus, in the postoperative period, it should be expected the appearance of symptoms of acute renal failure and various blood coagulation disorders (Shlapak et al., 2013).

For more effective redistribution of fluid from the interstitial space, Rheosorbilact solution might be administered as a part of infusion therapy. Hypertonic NaCl solution (7.5–10%) can also be used, which in the case of intravenous administration also contributes to the quick transition of an intracellular fluid into the intracellular space. This results in a gentle but not long-lasting increase in the volume of fluid in the vascular bed. In this case, so-called low-volume infusion therapy is carried out. Maximum recommended doses for 7.5% NaCl solution: 6 ml/kg for dogs and 4 ml/kg for cats.

The following approach is typical for current infusion therapy: if the program of infusion therapy is designed to administer a large volume of fluids, there must be a colloidal component in its composition. The ideal crystalloid/colloid ratio is 3:1. Thus, for each 100–150 ml of crystalloids, 40 or 50 ml of colloids should be infused depending on the clinical situation. Colloidal solutions must necessarily be included in the infusion program for patients with a blood level of total protein ≤ 35 g/L, albumin ≤ 20 g/L, anemia with hematocrit ≤ 20% or hemoglobin ≤ 70 g/L. Based on our practical experience, we recommend including in the program of infusion therapy, when guiding the animals with surgical pathology, dextran solutions (Polyglucin, Rheopolyglucin), hydroxyethyl starch (HES) (Refortan, Stabisol, Gecoton, Gecodez), and/or gelatin solution (Volutens, Gelofusine). The patient's condition should be monitored at the beginning of the infusion of these solutions, as they often have allergic reactions, in which case the infusion of this drug should be discontinued (Ko, 2019).

Intraoperative infusion therapy.

The main objectives of intraoperative infusion therapy are:

- elimination of fluid deficiency in diseased animal, which developed before the surgery;
- replenishment of physiological needs of the organism for fluid;
- replacement of pathological fluid losses that occur during the surgery.

Even if the patient is scheduled for planned surgery, he or she will have a certain fluid deficit before it begins. This is due to a 12–24 hour starvation diet before the operation. In addition, laxatives or enemas are often prescribed to prepare the intestine. These manipulations lead to loss of fluids and electrolytes, which is advisable to renew with balanced crystalloid solutions, e.g. Glykosteril F5, Normosol R, Sterofundin ISO, Plasma-Lyte, Hartmann (Battaglia & Steele, 2021).

It should also be taken into account that surgical trauma leads to varying degrees of fluid loss in tissues and its sequestration. This deficit is manifested by a decrease in the fluid volume in the interstitial and intravascular space (Shlapak et al., 2013).

The estimated amount of fluid to be administered to patients to compensate for the deficit and loss during surgery is calculated according to the commonly accepted formulas of infusion therapy.

The determined needs are met according to the following infusion therapy regimen. During the first hour, 1/4–1/3 of the volume of the balanced electrolyte solution is administered. After that, the infusion is administered at a rate of 5 ml/kg/h, increasing to 70 ml/kg/h for severe surgical trauma. The goal is to maintain diuresis > 1 ml/kg/h. When administering infusion therapy, first of all, pay attention to the patient's condition and changes in physiological indicators (temperature, blood pressure, breathing, pulse, and heart rate, presence of nasal dis-

charge, excitation, tremors, vomiting). If these signs occur, it is necessary to review the tactics and volume of infusion therapy in this patient. Sometimes it is better to administer a smaller volume of solutions rather than to deal with the consequences of excessive or rapid infusion (Butrov & Galenko, 2008).

Particular situations occur when there is severe bleeding during surgical intervention.

Massive surgical blood loss accompanies long-termed surgical interventions and is a specific critical condition that develops very quickly and, in the pathogenesis of which, severe persistent hypovolemia, anemia and threatened coagulopathy combined with severe shock-induced sympathoadrenal stress and inflammatory mediator release as well as body cooling are dominating (Gorobets et al., 2010).

These blood losses may occur during the surgical intervention and most often are associated with the complexity of the intervention. It is often necessary to take into account not only the need to remove the damaged organs within healthy tissues but also pathological angiogenesis that can lead to the severe vascularization of the surgical zone. Both of these factors can strongly influence the volume of blood loss (Gorobets et al., 2011).

However, several surgeries (especially large and unusual) are accompanied by massive blood loss, which requires an active infusion-transfusion therapy (ITT).

Traditionally, massive blood loss is a loss of more than 30% of total blood volume during 24 hours (30 ml/kg in dogs and 20 ml/kg in cats).

Rapid blood loss of the same volume due to damage of a large vessel during surgery (with correct actions of the surgeon and anesthesiologist) is usually easier to tolerate than prolonged bleeding during a long-term traumatic intervention (Gorobets et al., 2011; Rozanski & Rush, 2012).

The combination of hypotension, hypothermia, coagulopathy, and acidosis is a constant syndrome during the development of hemorrhagic shock, which maintains and strengthens the "vicious circle", and if it is not broken – the result will be unfavorable.

The basis of an effective ITT for high blood loss in the surgery:

- supporting sufficient preloading of the heart using intensive intravenous infusion;
- gradual manipulation with the composition of infusion with a focus on the volume of already lost and expected blood loss taking into account clinical characteristics and hematologic indices;
- timely use of cardiovasotonics (ephedrine, mesaton, noradrenaline, dopamine) for support of post- and preloading in cases of possible development of hemodynamic crisis and hypovolemic shock;
- prevention and treatment of hemostasis system disorders (Gorobets et al., 2011).

Eliminating the effects of massive blood loss, it should be borne in mind that bleeding occurs in a sick animal on the background of both the underlying disease and concomitant pathologies. Besides, the sick animal is put under anesthesia, which also affects its condition, and especially hemodynamics and compensatory reactions (Rozanski & Rush, 2012).

In most cases, it is only possible to estimate approximately the volume of blood loss during the massive blood loss. It is more or less accurate if most of the spilled blood enters a vacuum aspirator or a cavity from which it has been removed in a measuring container. The weighing of napkins soaked in the blood helps to estimate blood loss.

Calculations of blood loss by the level of hematocrit, albumin, platelets, and

red blood cells, all sorts of tables and devices are not accurate enough and require additional assistants, devices, and time.

In the intensive care of the massive blood loss, a major role is played by ITT phasing – the transition from the infusion of crystalloids and synthetic colloids to timely and reasonable transfusion of blood components (fresh frozen plasma, erythrocyte mass, whole blood, donor platelets) (Shlapak et al., 2013).

The principle of ITT phasing in case of ongoing bleeding allows the anesthesiologist to manage continuous intravenous infusion, maintaining the required circulating blood volume and not causing excessive hemodilution with loss of minimally acceptable coagulation potential and oxygen transport function of the blood (Gorobets, 2010).

Separately, it should be mentioned about urgent ITT for severe blood loss, which is characterized by quick loss of a large volume of the blood. In similar situations, the main task for the doctor who carries out ITT is to replenish the vascular bed as quickly and efficiently as possible (Table 2).

In 1944, the use of hypertonic NaCl solutions was suggested for the treatment of severe hemorrhagic shock. In 1980, I. Velasco has published experimental data on the improvement of the condition in dogs with simulated severe hemorrhagic shock.

Studies have shown that even at blood loss up to 50% of the circulating blood volume, infusion of 7.5% sodium chloride at a dose of 4 ml/kg is enough to restore cardiac output and regional blood flow (Galushko, 2011).

Bolus administration of 7.5% sodium chloride solution at a dose of 20–40 ml was associated with increased arterial blood pressure, restoration of consciousness, and improvement of urine excretion, i.e. there were signs of shock reversibility that is confirmed by studies in human medicine (Butrov & Galenko, 2008).

These works served as a basis for further research and the emergence of the concept of small-volume resuscitation as one of the methods of emergency therapy for different stages of shock and terminal conditions. This therapy is based on a rapid infusion of a small volume (4 ml/kg) of 7.2–7.5% sodium chloride and is associated with rapid mobilization of endogenous fluid into the vascular bed from the interstitium and intracellular space by the osmotic gradient. This solution in a volume of 250 ml has the same volemic effect as 1 liter of 5% albumin solution (Ko, 2019).

The hemodynamic effect of hypertonic solutions is very brief that is due to the rapid alignment of the osmotic gradient between the extracellular and intracellular sectors (Makintayr et al., 2012). The use of 5% glucose solution in the program of infusion therapy (renewal of circulating blood volume) is contraindicated.

To maintain the achieved increase in intravascular volume it was recommended to use hypertonic sodium chloride solution together with colloids (Shlapak et al., 2013). The obtained bicomponent solution, on the one hand, increases plasma osmolarity and mobilization of intracellular water (hypertonic component) and, on the other hand, it provides an increase in plasma oncotic pressure and preservation of intravascular volume (colloidal component) (Table 3).

Today it is believed that the most stable volemic effect is manifested when using a mixture of hypertonic NaCl solution with dextran or HES in a 1:1 ratio at a dose of 4–5 ml/kg (Belyayev et al., 2004).

One of such combined multicomponent solutions is Gekoton. The main active substances of the drug are the third-generation of hydroxyethyl starch 130/0.4, xylitol, and sodium lactate.

Gekoton belongs to the group of multicomponent colloidal hyperosmolar

solutions. Gekoton has hemodynamic, rheologic, anti-shock, and desintoxicating effects. After administration of the drug into the vein, the osmotic blood pressure is increased, the evacuation of fluid from tissues into the vascular bed is enhanced, impaired hemodynamics is restored, the microcirculation and blood rheological properties are enhanced, cardiac activity, the process of protein metabolism, desintoxicating function of the liver are increased in animals (Shlapak et al., 2013).

The maximum daily dose (in exceptional cases overdose is allowed) is 5–10 ml/kg/day.

Gelatin solutions are solutions that have a modified molecular structure. They are derived from denatured protein. This protein is extracted from the collagen tissue of cattle by thermal degradation, hydrolysis, and succinution. Gelatin drugs are isotonic, iso-oncotic (4–8%) gelatin solutions and low molecular weight (20000–40000 Da) plasma substitutes. Their pH is 7.1–7.7 and they create a colloid osmotic pressure of 33.3 mmHg or 453 mmH_2O, osmolarity – 274 mosmol/L, volume effect of these drugs is 40–100% (Pulnyashenko, 1997).

The meaning of blood dilution is in an effort to minimize the loss of formed elements at the stage of the surgery when blood volume loss is inevitable. If hemodilution does not cause clinically significant bleeding, it is possible to expect smaller losses of blood components (at the loss of equal volume) through low hematocrit. If the situation allows, it should

3. The main colloidal solutions from the arsenal of veterinary and human medicine that are used for the treatment of dogs and cats

Solution	Osmolarity, mosm/L	Colloid osmotic pressure, mmHg	Molecular mass, kDa	Volemic effect, %	Duration of therapeutic action, hour	pH
Dextrans						
10% Rheopolyglucin	310.0	90	35–45	200	3–4	4.5–6.5
6% Polyglucin	308.0	–	50–80	–	4–6	4.5–6.5
Gelatins						
4% Gelofusine	274.0	34	23	100	3–4	7.1–7.7
4% Volutens	274.0	34	30	100	3–4	7.4
First-generation of HES						
6% Stabisol	300.0	18	450	100	6–8	4.0–7.0
Second-generation of HES						
6% Refortan, 6% Gek-Infusion	300.0	28	200	100	4–6	4.0–7.0
10% Refortan, 10% Gek-Infusion	300.0	65	200	130	4–6	4.0–7.0
Third-generation of HES						
6% Voluven	308.0	36	130	100	4–6	4.0–5.5
Gecoton	890.0	–	130	100	4–6	5.5–7.5

be seek to restore red blood counts only after bleeding has stopped (Yin, 2008).

Fluid requirements during the postoperative period.

When calculating the level of infusion therapy for a sick animal in the postoperative period, several factors must be taken into account.

It is necessary to calculate the physiological needs of the animal, which is about 30 ml/kg/day for cats and 30–60 ml/kg/day for dogs. To this figure are added losses that are not perceived (through salivation, skin, and lungs): approximately 20 ml/kg/day and approximately the same amount is lost with fecal masses and urine. If a sick animal has a fever, it is necessary to add fluid in an amount of 4–8 ml/kg per degree of total body temperature above normal physiological indicators (Rozanski & Rush, 2012). Other losses (through probes, drains, etc.) are also taken into account.

Specific losses and fluid requirements (in cases of intestinal paresis, acute gastric dilatation with torsion, in case of loss into the third space after laparotomy and thoracotomy or massive tissue damage) should also be taken into account, during the first 24 hours after surgery it is necessary to give solutions at a level of about 4–15 ml/hour (100–400 ml/day), controlling indicators of the cardiovascular system and respiratory organs.

Conclusions and future perspectives

Before the planned surgery, the hemoglobin level should be within the range of 110–180 g/L for dogs and 80–150 g/L for cats, the hematocrit level should be not less than 37% for dogs and 26% for cats, and the albumin level should be not less than 25 g/L for dogs and cats. Also, it should be taken into account the animal's general condition and the presence of possible concomitant diseases.

The following approach is characteristic for the current infusion therapy: the ideal crystalloid/colloid ratio is 3:1. Thus, for each 100–150 ml of crystalloids, 40 or 50 ml of colloids should be infused, depending on the clinical situation. Colloidal solutions must be included in the infusion program for patients with a blood level of total protein ≤ 35 g/L, albumin ≤ 20 g/L, anemia with hematocrit ≤ 20% or hemoglobin ≤ 70 g/L.

When calculating the level of infusion therapy for sick animals in the postoperative period, several factors must be taken into account: calculate the physiological requirement in the animal, which is about 30 ml/kg/day for cats and 30–60 ml/kg/day for dogs and specific losses and fluid requirements.

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Анотація. Сучасний підхід у лікуванні тварин із хірургічною патологією вимагає введення інфузійних розчинів упродовж всього періопераційного періоду: до операції (при екстрених втручаннях), під час операції й після неї.

У тварин із хірургічними захворюваннями, які надходять на лікування, досить часто спостерігаються різного ступеня порушення водно-електролітного балансу. Причиною цих порушень є, як сама хірургічна патологія (наприклад, перитоніт, кишкова непрохідність), так і наявна в пацієнта супутня патологія (ниркова недостатність, цукровий діабет, серцева недостатність тощо). Від правильного оцінювання і корекції цих порушень багато в чому залежить успіх здійснюваного оперативного лікування.

У статті представлено сучасні підходи до проблем проведення інфузійної терапії у ветеринарній хірургії собак і котів.

Велику увагу приділено вибору засобів для інфузійної підтримки тварин у періопераційному періоді. Наведено приклади визначення об'єму розчинів для інфузії під час передопераційної підготовки, інтенсивної терапії масивної інтраопераційної крововтрати й післяопераційного ведення пацієнтів.

Ключові слова: *періопераційний період, інфузійна терапія, крововтрата, кристалоїди, колоїди, інфузійні розчини*