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The monograph contains new experimental results on the etiology, pathogenesis, diagnostics and methods of therapy for heart pathology in cattle. The assessment of the functional state of the heart of various technological groups of animals using clinical and instrumental research methods is described. Biochemical indicators for the diagnosis of myocardial dystrophy in high-production cows are determined.

The materials of the work are recommended to be used in the educational process during the teaching of clinical disciplines: "Clinical diagnostics of animal diseases", "Clinical biochemistry of animal diseases", "Internal diseases of animals" to applicants of secondary and higher educational institutions in the specialty "Veterinary medicine". The highlighted results will also be interesting for scientists and practical specialists of veterinary medicine working with high-yielding cows.

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INTRODUCTION

Livestock farming is one of the main agricultural sectors in Ukraine. In recent years, there has been a tendency to improve the genetic potential of dairy cows. Highly productive cows are quite demanding on their housing and feeding conditions [2], which, unfortunately, are often violated, leading to the development of pathologies such as ketosis, liver disease, rumen acidosis and alkalosis, ruminitis, rennet displacement, postpartum hypocalcaemia, secondary osteodystrophy, hypovitaminosis and other diseases [3]. About 10% of pathologies in these animals are associated with heart disease.

Diseases of the cardiovascular system in farm animals are actually more common than those diagnosed by specialists and recorded in veterinary records. They often occur as a complication of infectious, invasive, and many non-communicable diseases. Often, animals die after the underlying disease is eliminated due to irreversible toxic changes in the heart and blood vessels [4, 5].

Cardiac lesions often occur secondary to diseases caused by metabolic disorders, gynaecological, surgical, infectious and parasitic diseases, and acute or chronic intoxication. Their occurrence is facilitated by stress factors such as hypokinesia, crowding, and noise of the mechanisms in operation [4, 6].

Myocardial dystrophy occupies a special place among various non-inflammatory heart diseases. It has been proven that the disease can occur as a result of various diseases, including those not directly related to circulatory damage [7, 8].

1. CARDIOVASCULAR SYSTEM OF CATTLE

As is well known, the cardiovascular system of cattle consists of the circulatory and lymphatic systems, as well as the organs of haematopoiesis and immunogenesis. The main functional component of the cardiovascular system is blood, which flows through the blood vessels from the heart to provide all metabolically active processes in tissues throughout the body. Blood is a ‘car’ that transports nutrients, gases, hormones, metabolic products, etc. The vessels of the microcirculatory system exchange their contents with the interstitial tissues and fluids surrounding metabolically active areas of the body. In addition to transporting substances, blood also contributes to temperature regulation, acid base homeostasis, performs a protective function in terms of being the ‘host’ of the immune system, and also participates in the regulation of its own coagulation mechanisms.

The cardiovascular system as a whole, which includes the heart, blood and lymphatic vessels, ensures blood transport, metabolism between blood and tissues, humoral regulation and thermoregulation. In the course of phylogeny, the heart differentiated from a two-chamber to a four-chamber heart, developed a small circle of blood circulation and separated arterial and venous blood, transformed gill arteries and differentiated blood vessels. Changes in the circulatory system of mammals are reduced to the complete separation of venous and arterial blood flows. This is achieved by the complete four-chambered heart, reduction of the right aortic arch and preservation of the left aortic arch, which starts from the left ventricle.

The heart is the ‘pump’ of the cardiovascular system. It is built of cardiac muscle tissue surrounded by connective tissue and located in the chest cavity.

The main components of the vascular system are arteries, vessels that transport blood from the heart, and veins that deliver blood back to the heart. Between the arteries and veins are capillary connections, which are the site of exchange of nutrients, gas and other materials, between the cardiovascular system and interstitial tissue.

The lymphatic system is also worth mentioning here, as its role is mainly to return filtered plasma that has been released into the interstitial tissue and not

resorbed back into the cardiovascular system to prevent edema. The lymphatic system is also notable for carrying fatty acids and lipid-soluble vitamins from the small intestine back to the blood supply.

The heart is located in the thoracic cavity, which is located in the chest. The latter is covered with intrathoracic fascia and pleura. The parietal plate of the pleura is divided into rib and diaphragmatic plates. The right and left rib pleurae, descending from the dorsal wall of the chest cavity to the sternum, create the middle partition of the chest cavity - the mediastinum, which limits the serous mediastinal cavity. The mediastinum, in its dorsal third, contains the aorta, oesophagus, and trachea. Part of the mediastinal pleura is part of the core and is called the pericardial (core) pleura. The mediastinal pleura passes through the bronchi to the lungs, where it is called the pulmonary pleura. Between the three sheets of pleura (parietal, mediastinal and pulmonary) is the pleural cavity. It contains a small amount of serous fluid, which reduces friction between the serous laminae during breathing or heart function. The parietal lining of the pleura (rib lining) contains a large number of nerve endings and is more painful than the peritoneal (lung) lining during inflammatory processes.

The heart is located in the core (pericardium). It is attached to the spine by the heart vessels, and to the breastbone and diaphragm by ligaments. The pericardium is a protective sac that creates a safe place, called the pericardial cavity, in which the heart can function. The core consists of the outer and inner serous laminae, with a fibrous lamina between them. The outer serous lining is formed by the right and left mediastinal pleura, which is called the pericardial pleura. The pericardial pleura in the sternum passes into the rib pleura and thus forms the ligaments of the core. The fibrous leaflet of the core is derived from the intrathoracic fascia, which passes from the sternum to the core and also participates in the formation of the core ligament. The inner leaflet of the core is the parietal leaflet of a special serous membrane - the pericardium. The parietal leaflet of the pericardium at the base of the heart passes into the visceral leaflet and forms the serous membrane of the heart. Between these sheets there is a pericardial cavity filled with a small amount of transparent yellowish serous fluid.

The heart in cattle is located in the thoracic cavity between the lungs in the 3-6 intercostal space. The heart is divided into a dorsal heart base and a ventral heart apex, which looks like a hollow conical muscle. The base of the heart is located at the mid-third rib height line, and the apex is located in the sternum. The extended base is directed upwards, forward and to the right, and is located at the level of the shoulder joint. The pointed apex of the heart is directed downwards, backwards and to the left, not reaching the diaphragm and sternum, with which it is connected by the diaphragmatic-pericardial and sternocardial ligaments. The heart is displaced to the left of the median plane, and in the 3-4 rib region, it is adjacent to the left chest wall. Large blood vessels emanate from the base of the heart and enter it here: the aorta, pulmonary artery and cranial and caudal vena cava, as well as pulmonary veins.

Inside, the heart is divided by a septum into right venous and left arterial halves. Each half consists of an atrium and a ventricle. The atria, which are located at the base of the heart, and the ventricles, which make up most of the heart and form its apex, are connected by atrial and ventricular openings. In the atria, there is a blind triangular protrusion with ribbing on the free edge - the heart ears. The heart ears are directed cranially and are located to the right and left of the pulmonary arteries and aorta. They increase the volume of the atria. On the inner surface of the ears, there are scalloped muscles. At the base of the left and right atrial and ventricular openings are fibrous rings of dense fibrous connective tissue. The atria are located at the base of the heart: they are separated from the ventricles by a transverse coronal groove.

The ventricles make up most of the heart. On both surfaces of the heart, they are separated from each other by the interventricular subaxillary and circumcondylar grooves, which join on the cranial surface of the heart, not reaching its apex, and separate the right ventricle from the left. The apex of the heart in all animals belongs to the left ventricle, which is located to the left and rear, and the right ventricle lies in front and on the right. The interventricular furrows are also located accordingly: the sub-axillary furrow is more posterior and the circum-conical furrow is more anterior. The interventricular furrows of the heart contain blood vessels (Fig. 1.1).

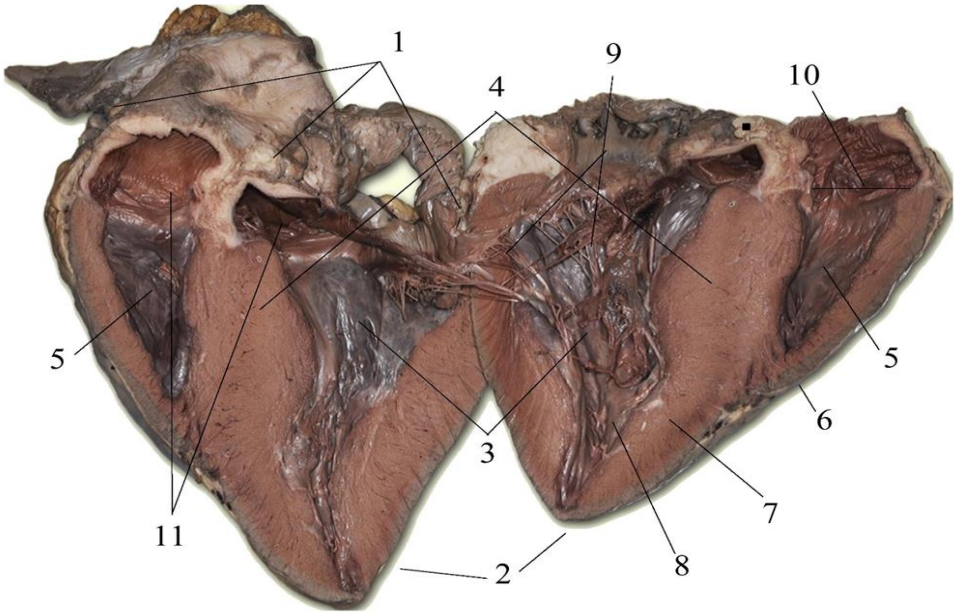

Figure 1.1. The heart of cattle: 1 – heart base; 2 – apex; 3 – left ventricle; 4 – septum; 5 – right ventricle; 6 – epicardium; 7 – myocardium; 8 – endocardium; 9 – heart strings; 10 – atrial ventricular opening; 11 -– atrium.

The trunk of the pulmonary arteries arises from the right ventricle and runs in the heart's base in front, between the atrial ears. Behind it is the aorta, which emerges from the left ventricle and runs caudally, like the pulmonary arteries. The right atrium includes the cranial and caudal venae cavae. The mouth of the cranial vena cava is called the venous sinus. Externally, it is separated from the auricle and atrium by a borderline furrow. The left atrium includes pulmonary veins, the number of which can be from 5 to 7.

There is a small indentation in the wall of the septum called the foramen ovale, which is the remnant of the foramen ovale. This is the opening that allows blood to move to avoid the pulmonary loop during fetal development.

The heart has a valve apparatus that ensures that blood flows in one direction. In the middle of the ventricles are the atrial-ventricular valves. On the right side there is a tricuspid valve and on the left side there is a bicuspid (mitral) valve. These valves have flaps that connect tendon strings attached to myocardial extensions called papillary muscles. There are corresponding valves in the openings of the aorta and the trunk of the pulmonary arteries. Each of them is formed by three flaps that look like crescent-shaped pockets.

Microscopic studies have confirmed that the heart wall is formed by the endocardium, myocardium and epicardium. In the endocardium, there are endothelial, subendothelial, muscular-elastic and connective tissue layers. The heart valves are formed by loose fibrous connective tissue, which is covered by the endocardium. The myocardium is formed by cardiac muscle tissue and layers of loose fibrous tissue, between which are vessels and nerves. The myocardium of the left ventricular wall is much thicker than that of the right ventricle. Cylindrical contractile cardiomyocytes are arranged in a chain and anastomosed to each other. Cardiomyocytes are connected to each other by means of insertion discs. The nuclei occupy a central position. Conducting cardiomyocytes form the conduction system of the heart, which is represented by the sinus atrial and atrial ventricular nodes, the bundle of His and its branches (Purkinje fibres). Conducting cardiomyocytes are located mainly at the border with the endocardium. The epicardium is formed by fibrous connective tissue covered with mesothelium (Fig. 2).

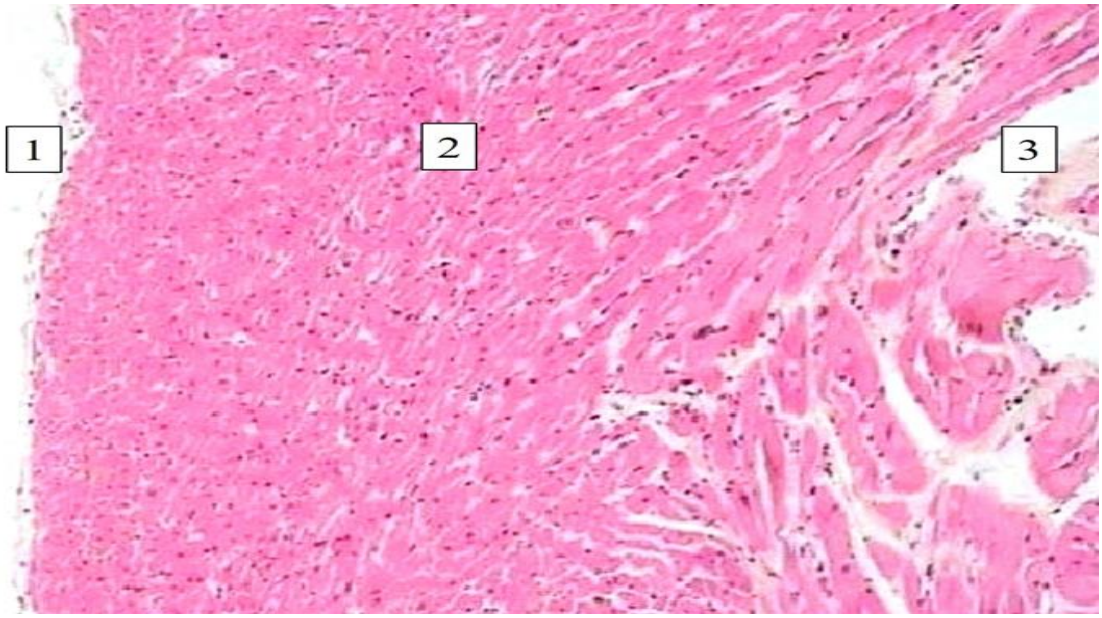

Figure 2. The histological structure of the normal cattle's heart: 1 – epicardium, 2 – myocardium, 3 – endocardium (haematoxylin and eosin × 5).

Thus, the heart muscle works continuously and rhythmically without stopping throughout the animal's life. This is the main physiological difference between the heart and skeletal muscles. Therefore, the heart muscle needs a constant supply of

oxygen and nutrients from the bloodstream. In order to understand its functioning or to develop the latest methods of prevention or therapy related to animal heart disease, it is first of all necessary to know the morphology of this organ in detail.

1.1. Etiology of heart disease in farm animals

Violation of the technology of rearing cows in industrial complexes can cause undesirable changes in animal systems and organs [12]. Increased milk production in cows is accompanied by activation of the cardiovascular system and increased blood filling of the mammary gland [13], which can lead to a weakening of heart function and the development of myocardial dystrophy based on physical overstrain [5].

According to the classification of G.F. Lang, all myocardial diseases are divided into two groups:

the first is inflammatory: myocarditis caused by infectious diseases; as a result, myocardiosclerosis develops;

the second group – myocardial dystrophy as a result of various intoxications, feeding disorders, changes in hormonal status, myocardial fatigue as a result of chronic mechanical impairment of its work or physical activity [14, 15].

Myocardial dystrophy (MD) develops as a result of various pathogenic factors. And although it can be considered a stereotypical process by origin, at the same time, specific manifestations may appear due to the peculiarities of the etiology and pathogenesis of the underlying disease. Therefore, it is generally accepted that myocardial dystrophy is a disease that develops secondary to the underlying disease [16].

V.H. Vasilenko et al. believe that myocardial dystrophy is caused by anaemia; malnutrition or obesity; vitamin deficiency; liver and kidney damage; metabolic disorders; endocrine system diseases; intoxication; physical overload; infections [17].

Many scientists [14, 16, 18] believe that the causes of myocardial dystrophy can be a) insufficient blood supply to the myocardium due to coronary artery disease, general circulatory failure, anaemia; b) heart muscle fatigue; c) changes in the physicochemical composition or physicochemical properties of blood; d) dystrophic

changes in infectious diseases; e) pathological changes in nervous effects on the myocardium, causing disruption of biochemical processes in the myocardium; f) hormonal changes in the myocardium.

In recent years, scientists have shown great interest in the study of myocardial dystrophy in various neuromuscular diseases. For example,

N.V. Samoilova and co-authors [19] found that the development of the disease may be due to recessive X-linked heredity.

The idea of excessive physical activity has been sufficiently confirmed in experimental studies. According to them, impaired adaptation of the circulatory system to hyperfunction is largely genetically determined and is more likely to develop in the heart with insufficient functioning of the ATP resynthesis and calcium pump systems [20]. In recent years, the issue of dysplastic cardiomyopathies has been increasingly discussed in connection with the development of inflammatory or infectious processes, such as rheumatic myocarditis and infective endocarditis, against this background [21].

Myocarditis is a disease characterised by lymphocyte infiltration and myocyte necrosis and can lead to sudden onset of heart failure [22].

Cardiac muscle damage in myocarditis can be caused by direct cytopathic effect of the pathogen, which can be localised both inside cardiomyocytes (viruses, chlamydia, rickettsia, trypanosomes) and in the interstitium (pathogenic bacteria) exposure to toxins secreted by pathogens directly in the myocardium or reaching it by haematogenous means (diphtheria myocarditis, streptococcal or staphylococcal infection with infectious and toxic shock); coronary artery endothelial damage with coronary artery disease (rickettsiosis); immune or autoimmune reactions.

There is a correlation between cardiovascular disorders and the nature of pathological processes in the lungs [24]. In the case of respiratory diseases, timely detection of cardiovascular pathology and pulmonary hypertension in the initial stages is of great importance, which is crucial in the prevention of myocardial dystrophy, chronic pulmonary heart disease, and circulatory decompensation [25]. Morphological changes in the pulmonary vessels develop in the event of a ventricular

septal defect [26].

Cardiohaemodynamic disorders in hypertension are determined by the structural and functional features of the myocardium and the development of heart failure. The link between liver damage and changes in the cardiovascular system has long been established by clinicians, but its mechanism remains unexplored. Diseases of the hepatobiliary system lead to disturbances in intracardiac and systemic haemodynamics, accelerating the development of the atherosclerotic process [27-29].

It has been established that the development of cardiovascular diseases is significantly accelerated with a progressive decline in renal function [31]. Calcification of heart valves is often observed in patients with chronic renal failure. The signs and pathological processes leading to the development of calcification of the aortic and mitral valves are different. For mitral valve calcification, the role of calcium-phosphorus metabolism disorders and prolonged duration of haemodialysis therapy is more specific [32].

According to L.O. Medvedyk et al [33], cardiac muscle diseases of non-coronary origin are caused by toxic substances - xenobiotics. Exposure to the latter causes hypertrophy of the myocardial walls. Dystrophy, fragmentation, necrosis of some cardiomyocytes and, as a result, uneven compensatory hypertrophy of other heart cells.

Prolonged keeping of cows in areas contaminated with radionuclides has a negative impact on the cardiovascular system, as evidenced by low electrical activity of the heart muscle, degenerative changes, coronary insufficiency, and ultimately strenuous heart work [34].

Barium chloride poisoning results in a sharp impairment of the functional state of the heart in all animals. On an electrocardiogram (ECG), this is manifested by changes in the basic functions of the heart: automaticity, excitability, and conduction [35].

Metabolic disorders in highly productive cows cause damage to various systems and organs, including the cardiovascular system [36]. Most often, heart disease occurs in the case of metabolic disorders: thyrotoxicosis, myxedema, obesity,

acromegaly, selenium, carnitine, calcium deficiency [37-39]; infectious (foot-and-mouth disease, bovine pasteurellosis) and parasitic diseases [40-42].

1.2. Pathogenesis of heart failure

Heart rate, along with contractility and left ventricular load, are key factors that determine myocardial oxygen consumption [43].

Modern research methods have shown that any dystrophic process is based on a violation of enzymatic reactions (enzyme pathology) in the metabolism (synthesis and decomposition) of substances with damage (alteration) to the structure and functions of the body's cellular and tissue systems [44-47]. Tissues accumulate metabolic products (changed both quantitatively and qualitatively), physiological regeneration (restoration of living matter, primarily at the molecular and ultrastructural levels of its organisation) and functions of a particular organ, as well as the vital activity of the body as a whole, are disrupted [48, 49].

Despite the variety of causative factors, myocardium develops a complex but essentially the same morphological reaction of allergic inflammation during inflammation: increased permeability of the vascular wall of the microcirculatory bed, activation of the complement system, which leads to the release of biologically active substances, development of immediate and slow hypersensitivity reactions [50].

The development of heart failure is associated with impaired systolic or diastolic myocardial function as a result of various destructive factors, including infections, ischaemia, and toxins. Hereditary factors also play an important role in heart muscle pathologies [51, 52].

Many genetic diseases are associated with mutations in cis-acting binding signals, but a small number of them are triggered by defective trans-acting binding factors. For example, the type-specific destructive factor SC35 in the heart provokes the development of dilated cardiomyopathy [53].

Various etiological factors cause disturbances in the mechanism of transformation and hormonal stimulation of genes in the process of developing heart

failure [54, 55]. Mutations of genes that are part of sarcomere protein complexes are characteristic of all cardiomyopathies [56-59]. About 300 dominant mutations in genes affecting myocardial ultrastructure are known [59]. The largest number of changes in sarcomere protein genes is observed in MYBPC3 and MYH7 [60, 61].

According to current concepts [62], a complex structural and functional restructuring of the heart in response to injury or overload, called remodelling, along with neurohumoral activation, is an integral part of the progression of chronic heart failure syndrome.

It is known that normal contraction and relaxation of the left ventricle is provided by both longitudinal and circular muscle fibres. The former predominate in the subendo- and subepicardial and papillary layers and papillary muscles, the latter in the middle layers of the myocardium. Longitudinal fibres contract faster than circular fibres. In case of pathology, the function of the former deteriorates first of all, and then the latter [63]. Given that the apex of the heart moves slightly during the cardiac cycle, the movement of the mitral annulus reflects well the contraction and relaxation of the left ventricular myocardium in the longitudinal direction, and therefore can be used to assess its contractile function [64].

The main substrates for energy production in the myocardium are free fatty acids, glucose, and lactate. At rest, 60 % of the oxygen absorbed by the myocardium, 23 % of glucose, 11 % of lactate, and 1 % of pyruvate are used for the metabolism of free fatty acids. During exercise, the metabolism of free fatty acids increases, whereas during hypoxia or ischaemia, the main substrate is glucose that enters the cell from the outside or intracellular glycogen. Energy formation includes 3 main stages: Stage I - intermediate metabolism, which results in the formation of oxidation substrates for their subsequent metabolism in the tricarboxylic acid cycle; Stage II - the tricarboxylic acid cycle (Krebs cycle), which involves aerobic oxidation of acetyl-CoA, a key intermediate in the metabolism of all essential nutrients, in the mitochondrial matrix; Stage III – oxidative phosphorylation.

Free fatty acids penetrate the cell membrane only together with L-carnitine, which is synthesised mainly in the liver and kidneys. If its synthesis is reduced,

phosphorylation is insufficient, which gradually depletes the myocardium [65].

The body's response to ischaemia is regarded as acute stress, which is reflected in the activity of processes that occur in the myocardium during the acute period of the disease [66]. Chronic hypoxia and ischaemia result in a restructuring of the isoenzyme spectrum of lactate dehydrogenase and creatine kinase in the myocardium [67].

Increased haemodynamics is a compensatory mechanism that causes the heart to work harder to support left ventricular emptying in case of mitral insufficiency and leads to a weakening of the functional capacity of the myocardium of this part of the organ [68]. Metabolic processes in the myocardium are very complex and mobile. Even a slight effect on the heart is clearly visible. It should be noted that the most noticeable changes are found in the energy supply of the organ.

Cardiomyocytes are finite cells, so their loss largely determines the degree of myocardial contractility impairment. Compensatory mechanisms are activated, the main of which is hypertrophy of the remaining viable cells. This is achieved by increasing the number of sarcomeres (structural proteins of the myocardium) in myofibrils, their thickening, and increasing the mass and number of mitochondria. These changes are of a low-adaptive nature, as there is a biological limit at which cardiomyocyte death occurs, accompanied by gene expression and then progressive impairment of cardiac contractility [69, 70].

Mitochondrial nitric oxide synthase and its cellular form produce NO, which is used by the cardiomyocyte as a sensor in the regulation of calcium transfer from the cell; in case of impaired production, the function of cell excitability is also impaired [71, 72].

In conditions of blood volume and pressure overload, the size of the left atrium increases in relation to the severity of mitral stenosis (narrowing of the bicuspid valve opening), however, the structural and functional restructuring of the left atrium does not ensure the restoration of its contractile and reservoir functions [73].

In myocardial ischaemia, in the perivascular space of coronary arteries in areas affected by atherosclerotic changes, there is a decrease in the density of nerve

plexuses, an increase in the number of atrophic neurocytes, and a decrease in the number of actively functioning perivascular neurocytes [72]. In addition, there is an increase in the activity of the intracardiac renin-angiotensin system [73].

Activation of the sympatho-adrenal and renin-angiotensin-adrenal systems in cardiomyopathies increases the synthesis and secretion of cytokines into the blood, the function of which is to coordinate the interaction of the immune, endothelial, endocrine and nervous systems in response to pathological stimuli (inflammation, stress, tissue damage). The pathological effects of cytokines are manifested in the following: negative inotropic effects; increased apoptosis of cardiomyocytes and skeletal muscle cells; activation of matrix metalloproteinases and impaired intracellular glucose transport; cardiac remodelling, which is manifested in irreversible dilatation of cavities and cardiomyocyte hypertrophy [50].

The pathogenetic mechanisms underlying cytokine-induced myocardial pathology are quite diverse and are associated with the synergistic activity of α-cell necrosis factor and other anti-inflammatory cytokines, in particular IL-6, in reducing the activity of nitric oxide synthetase in cardiomyocytes and endothelial cells of myocardial microvessels. Nitric oxide and the toxic product formed in the process of its interaction with superoxide anions, peroxynitrite, significantly reduce myocardial contractility [74-78].

Another important mechanism for reducing myocardial contractility is cardiomyocyte apoptosis, which can be induced by both the effect of anti-inflammatory cytokines and activation of free radical oxidation of cell membrane lipids [79-81].

Ventricular dilatation causes damage to its parietal part and provokes myocardial fibre hypertrophy. Completion of the pathological process is characterised by thinning of the heart wall. The process of myocardial reorganisation involves mediators with a complex interaction: the tissue renin-angiotensin system, angiotensin-II, aldosterone, endothelin, cytokines, interleukins. The consequences of these pathological changes in the heart are loss of introspection due to loss of cardiomyocytes, diastolic dysfunction due to fibrosis and collagen modification, and

the creation of favourable conditions for the development of arrhythmias [82].

The signalling cytokine suppressor (gene) SOCS-1 is an inducible cellular protein that can block or modulate signals from many cytokine receptors through signalling pathways. In the presence of homozygous inactivation of this gene, neonatal fatal fatty degeneration and liver necrosis, pathology of T and B lymphocyte development, and significant lesions of the heart, spleen, pancreas, and skin, accompanied by infiltration by macrophages and granulocytes, more often eosinophils, develop [83].

It is known that biometals, entering into invariant intra-systemic antagonistic/synergistic relationships, take an active part in the formation of a profile of dysregulatory, general metabolic disorders in myocardial infarction [84].

Baclofen, epinephrine, and norepinephrine can hyperpolarise the muscle membrane under conditions of electrogenic Na+/K+ pump and active Cl-ion transport [85].

Adenosine triphosphate-dependent K+ channels (ATP channels) are in a ‘closed’ state in healthy myocardium because they are inhibited by a high myoplasmic ATP concentration of 3-5 mM. When ATP decreases below 2 mM, they become ‘open’, which is observed in myocardial ischemia or hypoxia.

The thin filamentous protein cardiotroponin T (cTrT) is part of the tropomyosin conversion cycle, where two tropomyosins form a polypeptide ring. Changes that occur normally in filamentous protein during contraction are energetically disadvantageous for the body, so they are combined with hydrolysis by ATPase. This enzyme regulates the formation of ATP free energy in mitochondrial KATP channels, which, in the physiological state of cells, is in the form of ATP, ADP and intracellular phosphates [85, 86]. In the event of a violation of the integrity of the mitochondrial membrane and oxidative phosphorylation, ATP synthesis decreases and irreversible damage to cardiomyocytes occurs [87].

1.3. Clinical signs and diagnostics of heart failure

Functional assessment of the state of the cardiovascular system of lactating cows under conditions of their intensive use is very important, since the work of the heart can show the functional state of the whole organism [9].

Cardiac auscultation is one of the most important clinical methods for studying the cardiovascular system [18, 88]. Auscultation as a clinical examination method, in addition to its main purpose, has the following advantages: accessibility; allows you to choose additional research methods to make a final diagnosis [89]. However, according to some authors [88], these results are based on subjective perception.

At the first stage of auscultation, the heart rate is determined, and any abnormality (tachycardia or bradycardia) is the reason for electrocardiographic examination. Then the heart rhythm is determined. When listening to a physiologically healthy heart, 2 main tones are noted. The first (systolic) is muffled and prolonged (after it stops, a short pause follows); the second (diastolic) is clear, short, followed by a long pause [18, 90].

According to G. P. Novoshinov [91], the duration of the tones is determined by the species and age of the animals. The presence and intensity of cardiac murmurs is determined by the following reasons: the characteristics of the animal organism, the size of the valve defect, the heart rate, and the physical characteristics of the recording equipment.

Among the various methods proposed for the early diagnosis of cardiovascular disorders in animals, the measurement of arterial blood pressure is used in veterinary practice [92]. It indirectly reflects the state of blood circulation in the body [93].

One of the most effective methods for diagnosing heart function is ECG. Today, electrocardiography is receiving increasing attention [94]. The results of electrocardiography are widely used to assess the functional state of the cardiovascular system in animals, to determine the effectiveness of treatment of heart disease, as it is often necessary to determine their individual capabilities [95].

Electrocardiographic studies in different leads conducted by S.M. Chebunin [96] showed that ECGs obtained using conventional leads and reinforced unipolar

leads from the limbs are not stable, the recording is low-voltage, in quantity, and of poor quality in the form of artefacts: induced current from animal tremors, limb muscles, in case of limb movement to the side or forward. And, most importantly, the study does not take into account the anatomical and topographic features and the nature of the electrical activity of the heart. Sagittal, frontal, and enhanced unipolar leads proved to be the best in farm animals, and therefore are widely used in practical electrocardiography for these animals [96, 97].

Electrocardiographic examination is used in all cases of changes in the patient's clinical condition, when there are factors that cause ECG changes: disturbance of the ionic state of cardiomyocytes; anatomical modifications of the heart: hypertrophy and dilatation; lesions of the cardiac muscle tissue: degenerative changes, ischaemia; pericardial morphological modifications: pericardial transudate; neoplasms, pneumothorax, obesity; cardiac arrhythmias; disorders of the autonomic nervous system; iatrogenic effects of drugs whose cardiotropic effect is due to various mechanisms recorded by ECG; congenital and acquired heart disease [98-100].

The mild symptoms of myocardial dystrophy do not allow for a clear diagnosis of this disease using general clinical methods. The most characteristic diagnostic signs on the ECG are thickening, biconvexity, biphasic or inversion of the T wave, decrease or dome-shaped rise of ST segments from the isoline [101]. According to the results of L. I. Zolotova's research [8], there are no significant differences between the ECG and the symptoms of myocardial dystrophy developing against the background of various organ pathologies. Conduction in the atrial myocardium changes the least. The tendency to its slowing is documented by changes in the modified Macrouse index (PQ / P).

However, during the study, it is necessary to take into account the species-specific features of the cattle ECG, in particular: the presence of a negative T wave in the first lead, a negative or biphasic T wave in the second lead, and a positive T wave in the third lead [102].

Phonocardiography is much less commonly used to diagnose heart disease. According to the results of the study by O. I. Shchobak [104], spectral

phonocardiography allows recording sound vibrations of myocardial origin and differentiating them from vibrations of valvular origin.

Changes in the phonocardiogram in myocardial dystrophy are combined with a decrease in ECG wave voltages. The QRS complex is often expanded and deformed, the Q-T interval is prolonged, and the duration of the first (93 % of cases) and second (69 % of cases) tones increases [105].

Cardiac echography is a method of monitoring haemodynamics and the effectiveness of pharmacotherapy (metabolic drugs, cardiac glycosides, calcium antagonists). This method should be supplemented with Doppler echocardiography [106]. However, according to R. Y. Abdullaev [107], echocardiography is less sensitive than enzyme diagnostics.

1.3.1. Enzyme diagnostics of heart diseases

It is known that blood biochemical parameters in patients with cardiovascular disease are relatively stable [108]. In the diagnosis of myocardial diseases, along with typical clinical criteria and ECG changes, the determination of the activity of creatine kinase (CK), lactate dehydrogenase (LDH) and their isoenzymes, aspartate aminotransferase (AST) is widely used [109-111], as well as the blood content of myoglobin, myosin chains, cardiotroponins T and I [9, 112-114].

Under normal conditions, the activity of enzymes in the blood serum is relatively low compared to that in tissues [115, 116]. However, it should be noted that the enzymes used for diagnosis do not have organ specificity. They are found not only in the heart, but also in parenchymal organs, skeletal muscle, central nervous system, and other biological fluids [117, 118]. In the heart, the most active enzymes are lactate dehydrogenase (LDH), malate dehydrogenase (MDH), creatine kinase (CK), aspartate aminotransferase (AST), catalase, glycogen synthetase, 5′-nucleotidase, succinate dehydrogenase, and adenosine triphosphatase. According to N. S. Sazonova [119], the joint determination of the activity of MDH, LDH, CK, and thermostable LDH enzymes is of great help in the diagnosis of myocardial diseases.

Lactate dehydrogenase is one of the enzymes found in significant amounts in

all tissues [118]. In the event of damage to the myocardium, liver, kidneys, and other organs and tissues, the activity of lactate dehydrogenase in the blood serum increases. In the heart muscle, the isoenzyme LDH1 has the highest activity. Its activity in the blood serum increases in myocardial infarction, the isoenzyme spectrum of which resembles the isoenzyme spectrum of the heart muscle [114]. According to N. M. Zhukova [6], in cows with myocardial dystrophy complicated by ketosis, an increase in the activity of total LDH to 567.0±28.8 U/l and a decrease in the proportion of the cardiac fraction to 23.78±2.4 % were found.

Creatine kinase (CK) is mainly found in muscle tissue [114]. It transfers energy from the mitochondria to the sites of its use in the cardiomyocyte [120]. The activity of creatine kinase depends on the association of isoenzymes. The main isoenzymes that are important in the diagnosis of diseases are cardiac (KK-MB), muscle (KK-MM), and nervous (KK-BB) [121, 122].

A significant increase in serum creatine kinase activity is observed in skeletal muscle damage. Since skeletal muscle is not involved in the pathological process in acute coronary artery disease, an increase in serum creatine kinase activity in these cases unmistakably indicates myocardial damage [123-125]. The in vivo study by J. J. Bilandello et al. [10] on canine cardiomyocytes showed the release of CK-MB outside the cells upon their damage. Therefore, this test can be used for the early diagnosis of animal cardiomyopathies. Increased activity of the creatine kinase isoenzyme CK-MB is detected even before clinical signs appear, which allows for the highest diagnostic sensitivity of this test [9].

Aspartate aminotransferase is an enzyme that catalyses the intermolecular transfer of amino groups between amino acids and keto acids. It has been found that an increase in the level of this enzyme is characteristic of heart muscle damage [10]. According to Z. Stojević et al. [126], the activity of the enzyme varies from 32.9±7.06 in the dry period to 57.79±16.49 U/l in the first month of lactation and decreases at the end of lactation to 44.91±6.93 U/l.

Myoglobin belongs to chromoproteins. Like haemoglobin, it combines with oxygen and largely ensures the process of muscle respiration. In the event of heart

muscle damage, an increased myoglobin content in the blood serum is detected within 2-4 hours of the onset of clinical signs of the disease. Myoglobin is a marker of myocardial infarction that appears fastest in the blood serum and is used in diagnosis [9].

Troponin is a protein regulator of the thin filament of the striated muscle, which consists of 3 subunits I, T and C and is involved in the process of muscle contraction [127].

Troponin T (sTrT) is considered a marker of myocardial cell destruction. The appearance of troponin T in the blood indicates skeletal or cardiac muscle damage [128]. In acute myocardial infarction, cTrT is detected in the blood within 3 hours of the onset of the disease. The appearance of cTrT 10 h after the onset of an attack indicates myocardial necrosis. In cases where the interpretation of ECG or conventional laboratory parameters is difficult, the detection of cTrT indicates the presence of cardiomyocyte damage [129].

Troponin I (cTrI) is a regulatory protein that inhibits contraction in the absence of calcium. The cardiac isoform of this troponin is characterised by almost absolute specificity for cardiac muscle: cTrI is not detected in skeletal muscle under either physiological or pathological conditions. The pronounced organ specificity of troponin I allows it to be used as an informative indicator of cardiac muscle damage [9].

N.P. Kopytsia [130] found that in patients with left ventricular hypertrophy after myocardial infarction, a significant increase in inflammatory markers (C-reactive protein, anti-inflammatory cytokines) was found.

Lipid metabolism disorders are manifested by increased levels of total cholesterol and low-density lipoprotein. The increase in the activity of the release factor with an increase in the levels of high-density lipoproteins indicates that the latter contribute to the increased synthesis and release of substances that cause myocardial dilatation [131].

According to many authors [7, 20, 22, 101, 106, 113, 122, 128, 132], with the integrated use of instrumental and laboratory research methods, the diagnostic

accuracy is close to 98 %.

Nuclear magnetic resonance (NMR) imaging is considered to be very promising, as it allows visualising the heart and, together with spectroscopy, using radioactive phosphorus, quantifies the content of high-energy phosphates in cardiomyocytes and measures intracellular pH [133]. In clinical cardiology, NMR is used in the following cases: to build a chemical map of the heart; peripheral angiography; contrast imaging of the myocardium; radiographic studies using rhioactive isotopes of phosphorus, oxygen, sodium and carbon; coronary radiography; imaging of the intracellular lipid composition of cardiomyocytes; study of the kinetics of the tricarboxylic acid cycle [134–141].

1.3.2. Differntial diagnostics of heart diseases

It is known that blood biochemical parameters in patients with cardiovascular disease are relatively stable [108]. In the diagnosis of myocardial diseases, along with typical clinical criteria and ECG changes, the determination of the activity of creatine kinase (CK), lactate dehydrogenase (LDH) and their isoenzymes, aspartate aminotransferase (AST) is widely used [109-111], as well as the blood content of myoglobin, myosin chains, cardiotroponins T and I [9, 112-114].

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1.4. Treatment and prophylaxys of heart failure

The pathogenetic basis of most diseases of the circulatory system is the development of vasospasm, which results in an increase in vascular tone, impaired energy and plastic supply of the myocardium [161, 162]. The reasons for this may be both disruption of local mechanisms of vascular tone regulation and changes in the neurohumoral regulation of the body as a whole [163].

Modern medicine uses about 5000 substances, substances and preparations, of which approximately 2/5 of the active medicinal substances are obtained from medicinal plants. The use of substances of plant origin is due to their biological activity due to the presence of a biocomplex. The advantages of these drugs are their low toxicity and mild action [164, 165].

Cradioprotectors are a group of drugs with specific mechanisms of pharmacodynamic effects. They are divided into drugs of direct (true) and indirect action. The protective effect of direct cardioprotectors restores the energy function of cardiomyocytes. They include the following forms:

1. Drugs that regulate metabolic processes in the myocardium: drugs with a predominant effect on energy processes (trimetazidine, mildronate, phosphocreatine (neoton), ATP-long, Mexicor, carbonate); anabolic steroid and non-steroidal drugs (retabolil, nerobol, potassium orotate, riboxin, magnetite, etc.); peptide preparations (delargin), natriuretic peptide preparations (nesiritide, nesiritide, nesrizide, natrecor);

growth hormone preparation (gremlin); antioxidants (quercetin, lipin, lipoflavone, nicotinamide, thiotriazoline, cardnate, rhythmocor, corargin, ceruloplasmin); electron acceptors (ubiquinone, cytochrome c, etc.).

2. Drugs that affect mainly the electrolyte balance in the heart muscle: Selective slow potassium channel blockers (verapamil, diltiazem, amlodipine, lacidipine); Na+-K+ channel inhibitors (cariposide, rimeporide hydrochloride); drugs that open ATP-dependent K+ channels (nicorandil, levosimedan); drugs that stabilise the myocardial cell membrane – antiarrhythmic drugs (amiodarone, sotalol, ethacizine, propafenone, flecainide, etc.).

3. Bradycardic agents that suppress the activity of the sinus node (ivaberdin, etc.).

4. Medicines that reduce myocardial oxygen demand: organic nitrates (nitroglycerin, nitrone, isosorbide dinitrate, isosorbide mononitrate and a coronary dilator with a similar mechanism of action - molsidomine); β-blockers (metaprolol, bisoprolol), α-, β-blockers (carvedilol).

Indirect cardioprotectors include, first of all, antihypertensive drugs with different mechanisms of action: diuretics (spironolactone, eplerenol, indapamide, clopamide, furosemide); angiotensin-converting enzyme inhibitors (captopril, enalapril, fosinopril, lisinopril, perindopril, ramipril, spirapril, trandalopril); angiotensin II receptor antagonists (losartan, telmisartan, valsartan, candesartan, olmesartan); endothelin antagonists (bosentan); β-blockers that do not have a direct cardioprotective effect (atenolol, betaxolol, etc.); dihydropyrimidine calcium antagonists, except for amlodipine and lacidipine; neutral endopeptidase inhibitors (candoxatril, etc.); a drug that combines the properties of an angiotensin-converting enzyme inhibitor and a neutral endopeptidase inhibitor (omapatrilat) [165].

In addition, indirect cardioprotectors include antiplatelet agents such as acetylsalicylic acid, ticlopidine, clopidogrel, tirofiban, eptifibatide, integrilin, etc., as well as anticoagulants (heparin, fraxiparin, fondaparinus, etc.) [166, 167].

The basis of the existing therapy of myocardial dystrophy is the introduction of plastic material into the body: nucleic acid subunits - riboxin and its analogues, orotic

acid derivatives; potassium preparations, vitamin therapy, ATP, etc. It is useful to prescribe a complex of vitamins: A, B1, B6, B12, folic acid [169].

Cardiac glycoside drugs affect not only the cardiovascular system but also the nervous and urinary systems. Under their influence, a positive inotropic effect is realised, the minute and stroke volume increases, and other cardiac and systemic haemodynamic parameters change, characterising an increase in myocardial contractility and cardiac pumping function [166].

In the case of hypertension, diuretics are considered essential medicines. Genetic factors play a crucial role in pharmacotherapy, as in experimental animals [170] genetic variations account for 50 % of blood pressure variability [171]. Significant efficacy has been recognised in diuretics – potassium-sparing aldosterone antagonists spironolactone and more selective eplerenone [172], loop diuretics furosemide and safer torasemide, which causes less potassium loss after administration [173].

Saluretics are drugs that are widely used in heart failure. Today, the choice is limited to two groups of drugs: antialdosterones (spironolactone or verospiron) with mild and long-lasting effects, which are prescribed at an early stage of heart failure; diuretics that act at the level of the loop of Henle (furosemide, butamethadine), with a powerful and rapid effect, which are used to enhance the control of effusions [174-178].

Vasodilators are used from the very beginning of neurohumoral cardiac dysfunction, which have a certain etiological character. If the usual therapeutic doses of the drug are used, secondary effects in animals, unlike in humans, are much less frequent [179].

Nitric oxide (NO) activates guanylate cyclase, which leads to the formation of cyclic glucose metabolism and relaxation of smooth muscle cells, provokes vasodilation, which in a higher dose affects arteries and veins. However, the presence of an addictive phenomenon in relation to nitrate derivatives should be taken into account [180, 181].

The group of calcium inhibitors includes drugs with antiarrhythmic properties but a negative inotropic effect. Therefore, their use requires great caution in case of heart failure. In addition, the use of these drugs has not been shown to be superior to the use of conversion enzyme inhibitors [171, 182-186].

An analysis of the results of Y. M. Lopatin et al [187] shows that all long-acting calcium antagonists suppress the activity of the vagus nerve and increase the activity of the sympathetic division of the autonomic nervous system.

According to S. G. Yamashev [188], novocaine blockade in the stellate nodes is an effective method of pathogenetic therapy of experimental exudative pericarditis in cattle.

Drugs that inhibit platelet function (antiplatelet agents) are widely used in the treatment of coronary heart disease. They are used to reduce both the immediate and long-term risk of coronary artery thrombosis [189-192].

The effectiveness of aspirin in the secondary prevention of stroke has been confirmed by many studies. The relative risk of adverse outcome is reduced by 6.4 % [193]. The use of non-steroidal anti-inflammatory drugs, in particular diclofenac, has a positive effect on inflammation activity through normalisation of erythrocyte sedimentation rate (ESR), C-reactive protein, antibody titer to anti-streptohyaluronidase, restoration of functional activity of neutrophilic granulocytes, and reduction of pro-inflammatory cytokine IL-1 [194, 195].

The use of statins helps to reduce mortality from cardiovascular diseases by up to 42 % [196, 197]. R. M. Voskanyan et al. [198] recommend the use of aminazine at a dose of 2 mg per 100 kg of body weight for 8 days and irradiation with ultraviolet rays (PRK-7 lamp) for 20 minutes once every two days to normalise the function of the cardiovascular system in calves.

M. A. Litvinov [199] suggests that emergency therapy of hypertensive crisis in dogs should begin with intravenous administration of a 0.25 % solution of droperidol at the rate of 0.1 mg per 1 kg of body weight in a 5 % glucose solution in a ratio of 1 to 10, or intramuscular administration of a 2.5 % solution of aminazin at the rate of 0.5 mg per 1 kg of body weight. After 30-40 minutes, a 25 % magnesium sulfate

solution at a dose of 5-10 mg per 1 kg of body weight and a furosemide solution at a dose of 0.5 mg per 1 kg of body weight can be administered intramuscularly.

The administration of cathosal at a dose of 14-15 ml per cow (subcutaneously for 4 days) on the 2nd-15th day after parturition helps to improve the general condition of animals, cardiovascular and respiratory systems, optimise metabolism, reduce enzyme activity, restore the structure and function of the liver and kidneys [200].

Due to the recognition of the crucial role of immunopathological processes in the formation of myocarditis as a systemic response to a viral infection, it is optimal to use pathogenetic agents to limit the intensity of such reactions [190].

The results of the study by A. P. Ovcharova [201] showed that in patients with myocarditis who received intravascular laser irradiation of the blood in combination with quercetin and enterosgel, signs of general intoxication decreased 2-3 days earlier compared to patients who received conventional therapy. The use of enterosgel in the treatment is pathogenetically justified, as the drug helps to reduce the activity of the inflammatory process in the myocardium. U. Pasławska et al [202] performed a unique operation to implant artificial heart rate drivers (pacemakers) in dogs with cardiopathy. The animals were under constant ECG and echography monitoring.

Pastures are used to prevent cardiovascular disorders in cows exposed to low doses of radiation for a long time [203]. Physical activity has an active and direct effect on the nonspecific part of the immune system, regardless of intensity, which, in turn, has a positive effect on internal organs [204-206]. There is evidence that a ten-minute brisk walk (dosed functional test) is a moderate exercise for cows kept in free-range housing. A good functional condition of the body, in particular the cardiovascular system, makes it possible to quickly adjust the growing needs of the body with haemodynamic compensatory shifts. Such a course of metabolism, the nature of the electrocardiogram, haemodynamic changes indicate a good functional state of the organs of the cardiovascular system and the body of cows that were kept free-rang [207].

2. METHODOLOGY OF MEASUREMENTS

In medical practice, considerable attention is paid to biochemical diagnostic methods, in particular, to the determination of cardiac-specific isoenzymes CK and LDH [9]. There are no data on the activity of cardiac-specific isozymes in cows and their informativeness for the diagnosis of heart disease, which served as the choice of research methods.

To study the prevalence and causes of myocardial dystrophy, 290 highly productive cows (deep-calving, newly calving and early lactation) were studied, including 116 clinically healthy cows, 150 cows with myocardial dystrophy and 24 cows with hepatocardial syndrome, according to the following scheme: clinical examination, including tonometry and electrocardiography (ECG), and laboratory blood tests.

The functional state of the cardiovascular system was determined by general clinical (examination, palpation, auscultation) and special (Arterial blood preasure, ECG) methods. Electrocardiographic examination of 27 clinically healthy cows, 41 patients with myocardial dystrophy and 25 with hepatocardial syndrome was performed in frontal leads according to M. P. Roschevsky [208]. Relative atrioventricular conduction and systolic index were calculated from the ECG results.

The activity of creatine kinase (CK) and lactate dehydrogenase (LDH) and their cardiac-specific isoenzymes was determined in the blood serum: CK-MB (Biopharma kits) and LDH1 (Sewell-Tovarek method), as well as AsAT and AlAT (Reitman-Frenkel method), total protein (refractometric method), protein fractions (nephelometric method). The colloidal stability of blood serum was determined in reactions with 40 % formaldehyde and 0.1 % sulemic solution (according to Grinstead). In addition, the number of erythrocytes and leukocytes (diluted by the melange method), haemoglobin content (hemiglobin cyanide method), and haematocrit value (by microcentrifugation according to Shklyar) were determined. The hemoglobin content per erythrocyte (HCE) and average erythrocyte volume were calculated.

At the final stage of the experimental part of the dissertation, a comprehensive treatment regimen for high-yielding cows with myocardial dystrophy and hepatocardial syndrome was developed and tested on the farm. We treated 20 highly productive cows, including 10 with myocardial dystrophy and 10 with hepatocardial syndrome. There were 5 cows in the control group.

The results of the clinical study, biochemical blood tests and special methods were processed using the methods of variation statistics. The arithmetic mean (M), statistical error of the arithmetic mean (m), standard deviation (δ), and the probability of the difference between the arithmetic means of two variation series were determined by the probability criterion (p) and Student's tables. The difference between two values was considered significant when p was < 0.05, 0.01 and 0.001. The correlation between the features was determined by Pearson's correlation coefficient (r).

3. CLINICAL AND FUNCTIONAL STATE OF THE CARDIOVASCULAR SYSTEM IN CLINICALLY HEALTHY HIGH-YIELD COWS

In the practice of veterinary medicine, the cardiovascular system is examined in a certain sequence, starting with an examination and palpation of the chest in the heart area. Then, percussion of the heart area is performed to determine its percussion boundaries and to detect pathological conditions of the pericardium and myocardium. The main method of heart examination is auscultation. If necessary, additional (special) methods are used: electrocardiography, phonocardiography, sphygmography and phlebography, arteriography and phlebotonometry (blood pressure measurement), blood circulation rate, X-ray and ultrasound examination [18, 209].

The use of general clinical and special research methods (ECG, Atrerial blood preasure measurement) makes it possible to objectively assess the functional state of the heart in farm animals.

Studies of 116 clinically healthy deep-bodied and dairy cows revealed no edema in the underarm and limb area. Palpation of the heart area revealed that the heartbeat was localised, moderate, not painful, and rhythmic. Auscultation of the heart was found to be clean, clear, appropriate in timbre for healthy animals, without changes in tones.

Determination of the heart rate (HR) is an important diagnostic test, as changes in the heart rate, in particular tachycardia, are one of the clinical signs of heart failure [91]. We found that in 48 healthy high-yielding deep-bodied cows, the heart rate was on average 71±0.83 beats/min (58-78), in 26 newly calved cows – 72±0.7 (64-76), and in 42 clinically healthy dairy cows – 72±0.74 beats/min (60-80) (Table 3.1). That is, in clinically healthy cows, regardless of their physiological condition, the pulse rate was within the normative values, since 96.3–98.4 % of the values were in the range of M±2δ.

Since the pulse rate in cows of different technological groups does not differ significantly, we summarised the results of the study in all 116 cows. According to

these indicators, the pulse rate ranged from 58 to 80 beats per 1 min. Taking into account the value of the standard deviation (δ= ±4), it can be stated that in 78.5 % of cows the pulse rate is in the range of 68-76 beats/min (M±δ), and in 96.2 % – 64-80 beats/min (M±2 δ).

Table 3.1

Heart rate in clinically healthy high-yield cows

Indexes	Heart rate, bpm		
	Deep-calf cows (n=48)	Sprawling cows (n=26)	Early lactation cows (n=42)
Lim	58–78	64–76	60–80
M±m	71±0,83	72±0,7	72±0,74
δ	5	4	4
M±δ	66–76	68–76	68–76
M±2δ	61–81	64–80	64–80
p<	-	0,1	0,1

Note: p < compared to deep-calf cows

The lungs are closely related to the heart both topographically and functionally. In deep-calving cows, the respiratory rate per 1 min was in the range from 16 to 28 (22±0.49), in newly calved cows - 14-28 (22±0.7), and in cows of early lactation, respectively, 16-30 (23±0.54) respiratory movements /min (Table 3.2).

Table 3.2

Respiratory rate in clinically healthy high-yielding cows

Indexes	Breath rate, breat moves per minute		
	Deep-calf cows (n=48)	Sprawling cows (n=26)	Early lactation cows (n=42)
Lim	16–28	14–28	16–30
M±m	22±0,49	22±0,7	23±0,54
δ	3	4	4
M±δ	19–25	18–26	19–27
M±2δ	16–28	14–30	15–31
p<	-	0,1	0,1

Note: p < compared to deep-calf cows

Taking into account the value of the mean square deviation (δ = ±4), the respiratory rate in clinically healthy high-yielding cows of different physiological groups is in the range of 18-26 respiratory movements/min (M±δ), which account for

81.9 % of all values, while in the range of 14-30 respiratory movements/min (M± 2δ) – 100 %.

The calculation of the mean square deviation (±2δ) showed that the respiratory rate in high-yielding pregnant and dairy cows ranged from 14 to 30, which is slightly higher than according to the literature [210]. This is due to increased cardiac activity after transferring animals to tethered housing before calving (deep-calf cows) and high milk production, which requires an increase in oxygen supply to the organs.

Adaptation of the heart to the high workload of animals is one of the challenges of modern dairy farming. An important component of cows' adaptation is a prolonged increase in the intensity of the heart's work. Therefore, the study of the functional state of the myocardium is important for the early diagnosis and prevention of heart disease [211, 212]. In veterinary medicine, among the various methods for assessing the functioning of the heart of animals, the measurement of arterial blood pressure is important [92].

We found that blood pressure in clinically healthy deep-breasted cows was within the following limits: systolic blood pressure (SBP) – 110.0-130.0; diastolic blood pressure (DBP) – 30.0-60.0 and pulse pressure (PP) – 60.0-90.0 mm Hg, among newly calved cows, respectively, SBP - 110.0-130.0 mm Hg; DBP – 40.0-60.0; and PCP – 50.0-80.0 mm Hg (Table 3.3).

In early lactation cows, blood pressure values were: systolic – 119.0±1.94 (100.0-140.0); diastolic – 46.0±1.29 (30.0-60.0) and pulse – 73.0±2.37 (50.0-95.0) mm Hg (Table 3.3).

Since the difference between the groups of animals is not significant ($p<0.1$), by calculating the standard deviation of SBP, MAP (δ=±10.0) and DBP (δ=±7), we found that the physiological limits of ACP in 55 highly productive cows are within the following limits (M±δ) systolic – 110.0-130.0 mmHg; diastolic – 39.0-53.0 mmHg; pulse – 63.0-83.0 mmHg, with 98.2 %, 90.9 % and 83.6 % of cows within these limits. If we take into account M±2δ, then SBP values have limits of 100.0-140.0 mm Hg, within which 100 % of the values of all technological groups fall; DBP – 32.0-60.0 mm Hg – 98.2 %; PBP – 53.0-93.0 mm Hg – 96.4 % of all values.

Fluctuations in arterial pressure in high-yield cows are caused by increased blood circulation in the mammary gland, as about 500 litres of blood pass through it to produce 1 litre of milk [212].

Table 3.3

ABP values in clinically healthy high-yield cows

Indexes			Deep-calf cows	Sprawling cows	Early lactation cows
Arterial Blood Preasure, Mm Hg	SBP	Lim	110,0–130,0	110,0–130,0	110,0–140,0
		M±m	121,0±1,67	120,0±2,13	119,0±1,94
		δ	11	10	9
		M±δ	110,0–132,0	110,0–130,0	109,0–129,0
		M±2δ	99,0–143,0	100,0–140,0	99,0–139,0
		p<	–	0,1	0,1
	DBP	Lim	30,0–60,0	40,0–60,0	40,0–60,0
		M±m	46,0±1,55	47,0±1,88	46,0±1,29
		δ	7	7	6
		M±δ	39,0–53,0	40,0–54,0	40,0–52,0
		M±2δ	32,0–60,0	33,0–61,0	34,0–58,0
		p<	–	0,1	0,1
	PBP	Lim	60,0–90,0	50,0–80,0	50,0–90,0
		M±m	74,0±1,55	73,0±2,77	73,0±2,37
		δ	9	10	11
		M±δ	65,0–83,0	63,0–83,0	62,0–84,0
		M±2δ	53,0–92,0	53,0–93,0	51,0–95,0
		P <	–	0,1	0,1

Note: p < compared to deep-calf cows

The next method of studying the functional state of the heart is electrocardiography, which detects its disorders before the onset of clinical symptoms. In choosing the leads for ECG recording, we took into account the

topographic features of the animal heart [208, 214]. For cattle, sagittal and frontal leads proved to be the best [96, 215, 216]. We used frontal leads according to M.P. Roschevsky [216]. ECG recording was performed in 22 cows of different technological groups.

During the study of healthy cows (deep-calving and newly calving) in which ECG was recorded, the heart rate was 71.0±1.19 (68-74) beats/min.

The ECG analysis shows that the cardiac cycle in cows is rhythmic, since the maximum fluctuations in the duration of individual cycles (R-R) did not exceed 10% and were within ± 6.4%. The rhythm is sinus, the alternation of the teeth is sequential. In the first lead, the electrocardiogram is characterised by a positive P wave in 87.5 %, a ventricular complex of the QRS type and a negative T wave in 75 % of animals (Fig. 3.1).

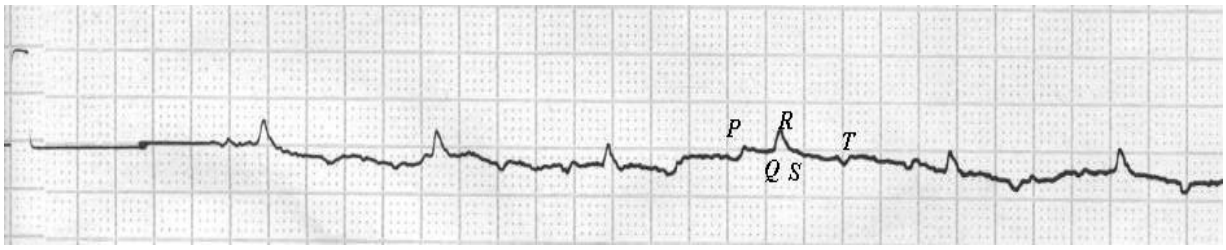

Figure 3.1. Electrocardiogram of a clinically healthy high-yielding cow in the first lead

The P-wave, consisting of an ascending knee with a small protrusion, a rounded apex, and a descending knee, is manifested with the onset of atrial excitation and reflects the process of its onset and passage. In cattle, this tooth is well defined, positive and often biphasic [217]. Its average value in the group of animals was 0.1±0.004 mV (0.08-0.12; Fig. 3.2).

The Q wave is the initial part of the ventricular complex of the electrocardiogram. It corresponds to the period of excitation of the right papillary muscle, interventricular septum, apex of the right and left ventricles, and base of the right ventricle [9, 96, 216]. We found that in clinically healthy cows, the Q wave is weakly expressed with an amplitude of 0.013±0.005 mV (0.0-0.038).

The most pronounced element in this lead is the R tooth, which consists

ofascending and descending cusps that form a sharp apex.

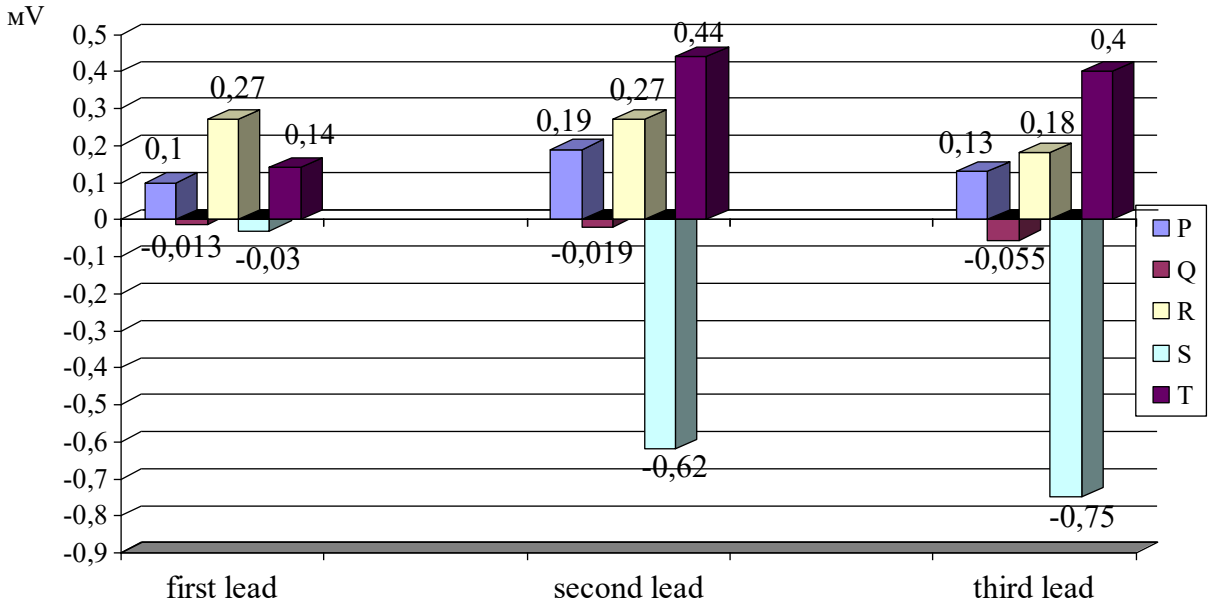

Figure 3.2. ECG waveforms in clinically healthy high-yield cows

The R wave indicates a gradual excitation of the ventricular myocardium [9, 215]. Its value averaged 0.27±0.047 mV with fluctuations from 0.14 to 0.4 mV (Fig. 3.2).

The S wave on the ECG is weakly expressed, directed downward from the isoelectric line and represents the terminal part of the ventricular complex, the descending knee of which is a continuation of the R wave [215]. Its amplitude is 0.03±0.004 mV (0.013-0.4) (Fig. 3.2).

The T wave is the terminal part of the ventricular complex. In cows, the T wave is characterised by a relatively large amplitude and may be negative in the first and third leads [9]. The value of the T-wave in clinically healthy cows was 0.14±0.022 mV with limits from 0.08 to 0.2 mV (see Fig. 3.2).

In the second lead, the ECG of clinically healthy cows is characterised by a positive P wave, ventricular QRS complex and T wave (Fig. 3.3). The amplitude of the P wave is 0.12-0.26 mV (0.19±0.023).

The negative orientation of the Q wave is weakly expressed and its voltage is

0.0-0.03 mV (0.019±0.005). The R wave has a value of 0.07-0.48 mV (0.27±0.073). The negative tooth S is the largest - 0.31-0.93 mV (0.62±0.11). The T wave was positive in all animals and its amplitude was 0.06-0.82 mV (0.44±0.068) (see Figs. 3.2 and 3.3).

In the third lead, the electrocardiogram is characterised by a positive P wave, ventricular complex, mainly of the QRS type (Fig. 3.4). The amplitude of the P wave is on average 0.13±0.014 mV (0.07-0.21). The negative Q wave is expressed in 75 % of animals and has a value of 0.055±0.009 mV (0.0-0.095), the amplitude of the R wave is on average 0.18±0.048 mV (0.03-0.3). The most pronounced element of the ventricular complex of the third frontal lead is the S wave, whose value is 0.75±0.149 mV (0.33-1.17). The T-wave has an amplitude of 0.4±0.07 mV (0.2-0.6) and is electropositive in 87.5% of animals (see Figs. 3.2 and 3.4).

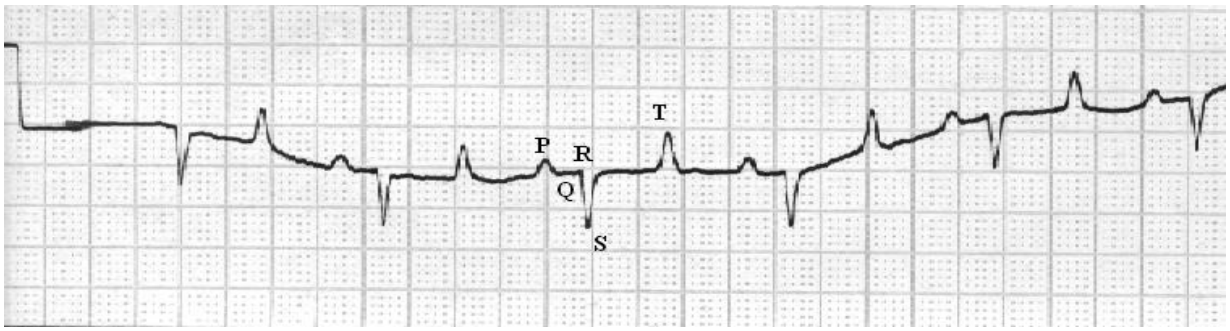

Figure 3.3. Electrocardiogram of clinically healthy cows from another breeder

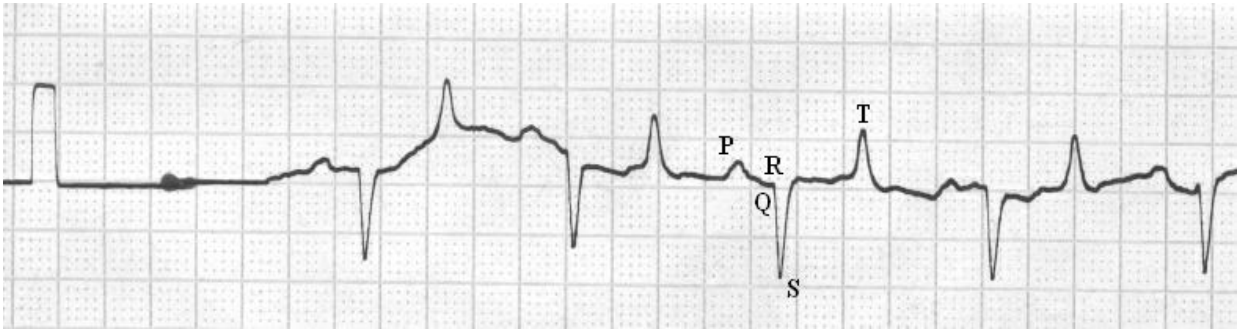

Figure 3.4. Electrocardiogram of a clinically healthy cow in the third breeding

An increase in the R-wave voltages was detected in 62.5 %, S – in 37.5 %, T-wave voltages were decreased in 25 % and increased in 62.5 % of animals. This is due to the system of keeping cows in our farms (tethered), as well as physiological characteristics, since ECG recording in all three leads was performed mainly on

pregnant cows (60 %). Thus, in dry animals in the last 3 months of pregnancy, sinus tachycardia, split teeth, and shifted intervals are observed. In cows of the first lactation, such changes are associated with the establishment of lactation function [97, 217-219].

When analysing the ECG, it is important to take into account not only the voltage of the teeth and their direction, but also the duration of the teeth and intervals, the results of calculations of individual indicators of the duration of the heart cycle (tabl. 3.4 i 3.5).

Table 3.4

ECG wave width in clinically healthy high-yield cows

Indexes		Wave width, sec		
		P	QRS	T
Deep-calf cows	Lim	0,06–0,1	0,04–0,09	0,09–0,15
	M±m	0,08±0,01	0,06±0,01	0,12±0,01
Milking cows	Lim	0,06–0,12	0,04–0,11	0,08–0,12
	M±m	0,08±0,01	0,06±0,01	0,11±0,01
p<		–	–	0,1

Note. p < compared to deep-calf cows

The duration of the cardiac cycle in pregnant and dairy cows was practically the same (Table 3.5), and the difference between pregnant and dairy animals was 6.4 %.

Table 3.5

Duration of ECG intervals in clinically healthy high-yield cows

Indexes		Wave width, sec			
		P-Q	Q-T	T-P	R-R
Deep-calf cows	Lim	0,12–0,19	0,25–0,41	0,27–0,51	0,79–1,19
	M±m	0,17±0,01	0,31±0,02	0,41±0,03	0,89±0,04
Milking cows	Lim	0,12–0,23	0,25–0,44	0,24–0,6	0,76–1,09
	M±m	0,17±0,01	0,34±0,02	0,35±0,04	0,86±0,03
p<		–	0,1	0,1	0,1

Note. p < compared to deep-calf cows

However, in dairy cows there is a tendency to reduce the duration of the diastolic period of the ECG (0.35±0.04 s), compared with dry cows (0.41±0.03 s), due to the opposite trend in the systolic period. The duration of atrial excitation is the

same (0.08±0.01 s), and its share in the cardiac cycle of dry cows is 9, dairy cows – 9.3 %.

Absolute atrioventricular conduction (PQ) in cows of both groups is the same (0.17±0.01 s), and relative (AP=(PQ:RR)-100 %): in pregnant cows it is 19.1±0.85 %, in dairy cows – 19.8±1.35 %. The duration of the ventricular QRST cycle in dairy cows tends to increase (0.34±0.02 s) compared to deep-calving cows (0.31±0.02 s), with the same duration of the QRS complex (0.06±0.01 s) and almost the same width of the T wave. Thus, the tendency to increase the duration of the ventricular QRST cycle in dairy cows is observed due to an increase in the duration of the period between the S and T waves (ST), that is, the period when the myocardium is in the stage of complete depolarisation, and this period lasts 0.17±0.01 s in them, compared to 0.13±0.01 s in pregnant cows ($p < 0,01$).

In the ECG analysis, attention is also paid to the systolic index - the ratio of the duration of electrical systole (QT) to the cardiac cycle (R-R), which is calculated using the Bazett formula (SP=(QT:RR)-100 %). It characterises the state of the cardiac conduction system [97, 211, 213]. In pregnant cows, the systolic index ranges from 25.0 to 45.0 % and averages 34.8±2.47 %, in dairy cows – from 28.3 to 48.3 % (39.5±2.17 %).

An increase in the duration of the systolic index in dairy cows indicates an increase in their heart function, which is associated with a significant increase in АИР (primarily systolic) [213, 216, 219].

The use of special methods of cardiac examination, such as ECG and tonometry, allows detecting changes in its functioning before the onset of clinical signs of pathology. Mostly, these changes occur as a result of the physiological characteristics of the cows we studied – pregnancy and the beginning of productivity.

Thus, in clinically healthy high-yielding cows, the heartbeat is localised, of moderate strength, the heart tones are clean, clear, and normal. The heart rate in high-yield cows is in the range of 64-80 beats per minute, maximum blood pressure – 100.0-140.0 mm Hg, minimum – 32.0-60.0, pulse – 53.0-93.0 mm Hg. ECG parameters within the limits established by us differ slightly from those given in the

literature [9, 97, 213, 217, 218], namely, reduced R wave voltage, increased S and T; increased R-R cardiac cycle duration and decreased Q-T, which is obviously due to the high productivity of cows.

The heart is the central organ of blood circulation. It meets the body's needs for oxygen through the coordinated functioning of the haematopoietic organs and blood flow in the vessels. Therefore, in case of heart disease, it is important to study the state of erythrocytopoiesis [18, 208–210].

In deep-calving clinically healthy cows (n=22), the number of erythrocytes was in the range of 5.0-8.0 T/l (6.6±0.15), in the blood of newly degenerated (n=12) and early lactation cows (n=21) – 5.2–7.2 T/l erythrocytes with an average value of 6.2±0.18 and 6.4±0.12 T/l, respectively (Table 3.6).

The calculation of the standard deviation (δ = ±0.7; n=55) revealed that 87.2 % of animals had a red blood cell count in the range of 5.7-7.3 T/l, and 100 % – 5.0-8.0 T/l. Therefore, the latter figure can be taken as the normal range for cows (5.0-8.0 T/l).

The haemoglobin content in the blood of deep-calving clinically healthy cows averaged 120.4±2.12 g/l (100.4-139.2; Table 3.5). Calculations of the standard deviation showed that 95 % of cows should have haemoglobin limits in the range from 100.0 to 140.0 g/l. This is somewhat higher than the values reported in the literature (95-125 g/l) [209, 210], and is obviously due to the increased oxygen demand of high-yielding cows. In the blood of newly calved cows, the haemoglobin content was on average 114.6±2.8 g/l (95.6-131.2), in dairy cows – 118.5±2.0 g/l (95.6-128.8).

Since the difference between the indicators of different physiological groups is not significant ($p < 0.1$), according to our calculations (δ = ±10.0; n = 55), the physiological limits of haemoglobin content in the blood are in the range from 100.0 to 136.0 g/l. Within these limits are 97.4 % of all haemoglobin values. A significant deviation of the upper limit is associated with the increased oxygen demand of high-yielding cows [209, 212]. In one deep-breasted animal (2.6 %), hyperchromemia was detected at the level of 139.2 g/l, but other indicators of erythrocytopoiesis (red blood

cell count, HbE and mean erythrocyte volume) were within the physiological range (7.9 T/l, 17.6 pg and 59.5 μm3, respectively). The increase in haematocrit value to 0.47 l/l is proportional to the number of red blood cells.

The hemoglobin content per erythrocyte (Hb) in clinically healthy deep-calving cows was in the range of 15.4-20.6 pg with an average value of 18.2±0.29 pg, in newly calving cows - from 16.3 to 20.2 pg (18.5±0.35), in early lactation cows - 15.6-19.8 pg (18.5±0.2) (Table 3.6). Having calculated the standard deviation in all groups (δ=±1.2), we established physiological limits of BSE for high-yielding cows - 15.5-21.0 pg.

Table 3.6

Indicators of erythrocytopoiesis in clinically healthy high-yield cows

Indexes		Deep-calf cows	Sprawling cows	Early lactation cows
Heamoglobin, g/l	Lim	100,4–139,2	95,6–131,2	98,0–128,8
	M±m	120,0±2,12	114,6±2,8	119,2±0,94
	M±δ	110,0–130,0	105,6–123,6	109,5–127,5
	M±2δ	100,0–140,0	96,6–132,6	100,5–136,5
RBC, T/l	Lim	5,8–8,0	5,2–7,2	5,2–7,2
	M±m	6,6±0,15	6,2±0,18	6,4±0,12
	M±δ	5,9–7,3	5,6–6,8	5,9–6,9
	M±2δ	5,2–8,0	5,0–7,4	5,4–7,4
MCH, pg	Lim	15,4–20,6	16,3–20,2	15,6–19,8
	M±m	18,2±0,29	18,5±0,35	18,5±0,25
	M±δ	16,9–19,5	17,3–19,7	17,4–19,6
	M±2δ	15,6–20,8	16,1–20,9	16,3–20,7

An objective indicator of erythrocytopoiesis is the haematocrit value - the ratio of red blood cell volume to the total volume of blood taken [209-211]. In clinically healthy deep-calving cows, the average value of haematocrit was 0.38±0.01 l/l (0.32-0.47 l/l), in newly calving cows – 0.35±0.01 l/l (0.29-0.41), and in the group of early lactation cows – 0.34±0.01 l/l (0.27-0.43 l/l), which is significantly lower ($p < 0.05$) than in deep-calving cows (Table 3.7). This may be due to an increase in the amount of blood plasma used for milk secretion in dairy cows [210]. The physiological limits of haematocrit value (δ=±0.04, n=55) for high-yielding cows are in the range from 0.27 to 0.45 l/l, which includes 99.1 % of all values.

The haematocrit value depends on two indicators: the number of red blood cells and their average volume. The average volume of red blood cells in deep-calving cows is 57.4±1.33 (46.1-67.7) μm3, in newly calved cows - 57.0±1.76 (44.4-63.3) μm3, and in early lactation cows - 53.6±1.39 μm3(41.7-66.2) (Table 3.7), which is significantly lower ($p<0.05$) than in deep-calving animals.

According to the calculations of the mean square deviation (δ= ±6.0; n=55), the average red blood cell volume in 95 % of high-yielding cows should be in the range from 44.0 to 68.0 μm3. According to the results of our research, 98.3 % of such cows were in this range.

In high-yielding cows, red blood counts are somewhat higher than the norms generally accepted in the literature [210], with the exception of the haematocrit value. This is due to the increased oxygen and nutrient requirements of high-yield cows [18, 211, 219].

Table 3.7

Indicators of haemocytopoiesis in clinically healthy high-yield cows

Indexes		Deep-calf cows	Sprawling cows	Early lactation cows
Heamatocrit, l/l	Lim	0,32–0,47	0,29–0,41	0,27–0,43
	M±m	0,37±0,01	0,35±0,01	0,34±0,01*
	M±δ	0,33–0,41	0,31–0,39	0,3–0,38
	M±2δ	0,29–0,45	0,27–0,43	0,26–0,42
MCV, mcm^3	Lim	46,1–67,7	44,4–63,3	41,7–66,2
	M±m	57,4±1,33	57,0±1,76	53,6±1,39*
	M±δ	52,1–62,7	51,0–63,0	47,2–60,0
	M±2δ	46,8–68,0	45,0–69,0	40,8–66,4
WBC, G/l	Lim	5,8–8,0	5,2–7,2	6,0–8,5
	M±m	6,6±0,15	6,9±0,24	7,0±0,18
	M±δ	5,6–7,6	6,0–7,9	6,0–8,0
	M±2δ	4,6–8,6	5,1–8,8	5,0–9,0

Note. * – $p< 0.05$ compared to deep-calf cows

The number of leukocytes in the blood of deep-calving clinically healthy cows is in the range of 5.8-8.0 G/l with an average value of 6.6±0.15 G/l, in newly calving cows – 5.2-7.2 G/l (6.9±0.24 G/l), in animals of early lactation - 6.0-8.5 G/l (7.0±0.18

G/l; Table 3.7).

The total number of leukocytes in the blood of high-yielding cows of all physiological groups ranged from 5.0 to 9.0 G/l. The calculation of the standard deviation (δ=±1.0, n=55) showed that 95 % of cows should be in the range of 4.8-8.8 G/l.

The morphological examination of the blood of high-yielding cows revealed insignificant fluctuations in haemoglobin content, red and white blood cell counts, haematocrit and red blood indices between different technological groups. In deep-calf cows, an increase in haemoglobin concentration is a physiological phenomenon. In dairy cows, changes in red blood counts are caused by the increased need for nutrients for milk production.

4. ACTIVITY OF CREATINE PHOSPHOKINASE, LACTATE DEHYDROGENASE AND THEIR CARDIOSPECIFIC IZOENEMES (CK-MB; LDH1) IN BLOOD SERUM OF HIGHLY PRODUCTIVE COWS

Modern research methods have established that any dystrophic process is based on a violation of enzymatic reactions in metabolism with subsequent damage to the structure and changes in the functional state of the body. Tissues accumulate metabolic products that are altered in quantity and quality, which leads to cell damage [47]. Depending on the magnitude of the disorders, disorganisation of the enzyme system occurs - enzyme pathology, which can manifest itself as clinical symptoms or be asymptomatic [211]. Based on this, the determination of the activity of enzymes and their isoforms is successfully used to diagnose pathology of various organs. Enzyme diagnostics is particularly informative when the enzyme is localised in only one organ. Such enzymes are called organ-specific. Some enzymes have isoenzymes that are unique to certain organs. For example, the heart muscle contains the first fraction of LDH, LDH1, and the myocardial isoenzyme CK, CK-MB [125, 128, 132].

The organ-specificity of isoenzyme diagnostics of heart disease is based on the difference in the ratio of LDH and CK isoenzymes in individual organs, and therefore in the blood serum in case of their damage [219-221].

Creatine kinase is an enzyme that catalyses the phosphorylation of creatine with the participation of adenosine triphosphate. Skeletal muscle is the richest in it, but a significant amount is found in the heart muscle, brain, thyroid gland, and lungs. The enzyme activity is low in the liver and red blood cells [125]. In the blood serum, CK is present in the form of the following isoenzymes: cardiac CK-MB, muscle CK-MM, and brain CK-BB [128].

A study of the serum of 10 clinically healthy deep-calving cows revealed that the activity of total creatine kinase was in the range of 22.0-55.0 U/l, and its cardiac isoenzyme – 2.8-8.3 U/l. The ratio of CK-MB/CK-NAC was 5.1-37.7 % (Table 4.1).

In the group of clinically healthy newly bred cows (6 heads), the activity of

CK-NAC and CK-MB in the blood serum was 24.8-100.4 and 5.5-19.3 U/l, respectively. The ratio of CK-MB/CK-NAC was in the range of 10.0-34.6 % (Table 4.1). In one animal (16.7 %), hyperfermentemia of total CK (100.4 U/l) was detected, which may be caused by an increase in the activity of muscle or brain isoenzymes, since the activity of CK-MB in this animal was within the normal range (19.3 U/l).

Table 4.1

Activity of CK-NAC, CK-MB and CK-MB/CK-NAC in clinically healthy high-yielding cows

Indexes		Deep-calf cows	Sprawling cows	Early lactation cows
CK-NAC, U/l	Lim	22,0–55,0	24,8–100,4	30,3–61,3
	M±m	35,1±4,35	53,2±10,43	41,9±3,86
	M±δ	25,0–45,0	30,0–80,0	30,0–52,0
	M±2δ	15,0–55,0	5,0–105,0	18,0–65,0
	p<		0,1	0,1
CK-MB, U/l	Lim	2,8–8,3	5,5–19,3	2,8–18,0
	M±m	6,0±0,84	10,2±2,19	9,8±1,82
	M±δ	4,0–8,0	5,0–15,4	5,0–14,6
	M±2δ	2,0–10,0	0,0–20,6	0,2–19,4
	p<		0,1	0,1
CK-MB/CK-NAC, %	Lim	5,1–37,7	10,0–34,6	8,9–35,8
	M±m	17,1±4,48	19,2±4,36	23,4±3,2
	M±δ	6,0–28,0	10,0–28,4	14,0–32,0
	M±2δ	0,0–40,0	0,8–37,6	4,0–42,0
	p<		0,1	0,1

Note. p< – compared to deep-calf cows

The activity of total creatine kinase and its cardiac isoenzyme in the blood serum of 8 clinically healthy high-yielding cows of early lactation ranged from 30.3-61.3 U/l and 2.8-18.0 U/l, respectively, and the ratio of CK-MB/KK-NAC ranged from 8.9 to 35.8 % (see Table 4.1).

The physiological limits of creatine phosphokinase and its isoenzyme in cow serum were determined by calculating the standard deviation (±2 δ, n = 24). Thus, the limits of KK-NAC (δ=±16.0) should be from 10.0 (min) to 80.0 (max) U/l, and CK-MB (δ= ±4.8) – 1.0-20.0 U/l. The proportion of cardiac-specific isoenzyme (CK-MB) (δ= ±10.0) in the structure of total creatine phosphokinase is normally 10.0-40.0 %. We have established a medium correlation between the values of total creatine kinase activity in the blood serum and its cardiac-specific isoenzyme (r = +0.49).

Lactate dehydrogenase (LDH) is a cytosolic zinc-containing enzyme that catalyses the oxidation of L-lactate to pyruvic acid. It is widely distributed in cells of various organs, i.e. it is a relatively nonspecific enzyme, which reduces its diagnostic value in determining the overall activity [128]. Its spectrum includes 5 isozymes, whose profile is quite specific and identical. Thus, the heart mainly contains LDH1, the lungs – LDH2 and LDH3, and the liver – LDH4 and LDH5 [6, 18, 220, 222].

The activity of LDH1 isoenzyme is characteristic of myocardium as a tissue with an anaerobic type of glycolysis. In the case of myocardial hypertrophy and chronic hypoxia, the synthesis of LDH1 in cardiomyocytes begins to increase, and in the acute course of myocarditis, the LDH1/LDH ratio is disturbed, so it is important to determine the activity of LDH isozymes [239].

We found that the activity of total LDH and its myocardial isoenzyme in the blood serum of clinically healthy deep-calf cows was at the level of 151.0-442.0 and 78.0-254.0 U/l, respectively. The proportion of cardiac isoenzyme in the total activity of LDH is in the range of 26.3-52.3 % (Table 4.2).

Table 4.2

Activity of LDH, LDH1 та LDH1/LDH in blood of clinically healthy high-yielding cows

Indexes		Deep-calf cows	Sprawling cows	Early lactation cows
LDH, U/l	Lim	151,0–442,0	242,0–396,0	215,0–447,0
	M±m	332,6±16,92	337,2±16,04	314,8±14,5
	M±δ	260,0–400,0	290,0–390,0	250,0–380,0
	M±2δ	190,0–470,0	240,0–440,0	180,0–450,0
LDH_1, U/l	Lim	78,0–188,0	111,0–184,0	64,0–199,0
	M±m	143,8±7,84	152,2±6,5	139,0±7,93
	M±δ	110,0–180,0	130,0–170,0	100,0–180,0
	M±2δ	75,0–215,0	110,0–190,0	60,0–220,0
LDH_1/LDH, %	Lim	33,7–52,3	40,4–48,8	16,2–55,4
	M±m	44,9±1,81	45,3±0,73	42,2±2,02
	M±δ	37,0–53,0	43,0–48,0	33,0–51,0
	M±2δ	29,0–61,0	40,0–50,0	24,0–60,0

Note. $p < 0,1$, compared to deep-calf cows

In the blood serum of clinically healthy newly degenerated animals, the activity of LDH and LDH1 was 242.0-396.0 and 111.0-184.0 U/l, in early lactation cows, respectively, 215.0-447.0 and 64.0-199.0 U/l. The share of myocardial isoenzyme in

the total activity of LDH in newly calved cows is 40.4-48.8 %, in early lactation cows – 16.2-55.4 % (Table 4.2).

By calculating the standard deviation (± 2 δ, n=46), we found that the physiological limits of total lactate dehydrogenase (δ=±64.0) in the blood serum of 95.0 % of high-yielding cows are 200.0-455.0 U/l, and its cardiac-specific isoenzyme (δ=±33.7) – LDH1– 80.0-215.0 U/l. The proportion of LDH1 (δ=±7.5) in the structure of total lactate dehydrogenase is normally 30-56 %.

Therefore, for LDH analysis, it is necessary to take into account the activity of the LDH1 isozyme and its share in the total enzyme activity, which gives a clearer picture of the biochemical processes taking place in the heart muscle. An increase in total lactate dehydrogenase activity may be caused by isoenzymes specific to the liver and lungs.

For a complete analysis of the activity of total CK and LDH, it is necessary to take into account the activity of their cardiac isozymes and the percentage of CK-MB/CK-NAC and LDH1/LDH. These indicators indicate biochemical changes that occur in cardiomyocytes in cardiac pathology.

In addition to cardiac-specific isoenzymes, other enzymes are localised in cardiomyocytes, including AsAT and AlAT, which are not organ-specific, as they are localised in cells of different organs: liver, kidneys, skeletal muscle, and less in the pancreas, spleen, and lungs [223]. Changes in serum AsAt activity are used in humane medicine to confirm the diagnosis of myocardial infarction and to identify liver disease [117].

In the blood serum of deep-calf cows, the activity of asparagine transferase was in the range of 1.58-2.33 mmol/h × l (1.87±0.05), newly calved cows – 1.65-2.31 (1.91±0.06), and early lactation cows – 1.47-2.33 mmol/h×l (1.88±0.06; Table 4.3).

Having calculated the standard deviation (±2 δ, n=53) and the mean value of the enzyme activity (1.82±0.03), we established physiological limits of AsAT activity (δ=±0.26) in high-yielding cows – from 1.4 to 2.34 mmol/h × l.

In the blood serum of high-yielding deep-calf cows, AlAt activity was in the range of 0.43-1.04 mmol/h × l, in newly calved cows – 0.61-0.96 mmol/h × l, in early

lactation cows – 0.52-1.08 mmol/h × l (Table 4.3).

Table 4.3

Activity of AsAT and AlAT in clinically healthy high-yield cows

Indexes		Deep-calf cows	Sprawling cows	Early lactation cows
AsAT, mmol/h×l	Lim	1,58–2,33	1,65–2,31	1,47–2,33
	M±m	1,87±0,05	1,91±0,06	1,88±0,06
	M±δ	1,63–2,11	1,69–2,13	1,62–2,14
	M±2δ	1,39–2,35	1,47–2,35	1,38–2,4
	p<		0,1	0,1
AlAT, mmol/h×l	Lim	0,43–1,04	0,61–0,96	0,52–1,08
	M±m	0,77±0,04	0,78±0,03	0,85±0,04
	M±δ	0,6–0,94	0,68–0,88	0,69–1,01
	M±2δ	0,43–1,11	0,58–0,98	0,53–1,17
	P <		0,1	0,1

Note. p< – compared to deep-calf cows

After calculating the standard deviation (± 2δ; n= 53), we established physiological limits for the activity of alanine transferase (δ=±0.16) in the blood serum of highly productive cows.

They should be in the range of 0.48 to 1.12 mmol/h × l. Alanine aminotransferase, like asparagine aminotransferase, is widely distributed in tissues, but the largest amount is found in the liver. Accordingly, the determination of the activity of this enzyme in the blood serum is of great diagnostic value for the confirmation or exclusion of liver disease [125].

Increased activity of AlAt and AsAt is detected in the case of liver, heart, and skeletal muscle pathologies, so additional tests are used to differentiate these pathologies. Nevertheless, their hyperfermentation is more often an indicator of pathological changes in hepatocytes. In contrast, the activity of myocardial isoenzymes LDH and CK is a specific test of the functional state of the heart.

5. PREVALENCE AND MAIN CAUSES OF MYOCARDIAL DYSTROPHY IN HIGH-YIELD COWS

Achieving high dairy productivity in cows primarily depends on adequate feeding combined with sufficient genetic potential and optimal housing technology that meets the biological characteristics of the animals. The organisation of cow feeding and management is based on scientific principles, i.e. knowledge of the biological needs of animals according to their physiological state, age, body weight and level of productivity [224].

In industrial complexes, it is especially important to strictly adhere to the technology of animal rearing, the violation of which can cause undesirable changes in systems and organs [225]. Deviations from optimal feeding and housing conditions, along with insufficient exercise and intensive use of animals, lead to additional stress on physiological processes, which causes diseases of the cardiovascular system.

Increased milk production in cows is accompanied by activation of the cardiovascular system and increased blood filling of the mammary gland, which can lead to a weakening of heart function and the development of myocardial dystrophy based on physical overstrain [4]. Morphological changes in the heart in high-yielding cows were first identified by the prominent pathologist V.P. Shishkov almost 50 years ago [226]. He found that dystrophic and necrotic changes predominate in the myocardium, while inflammatory processes occur in isolated cases.

Out of 107 studied deep-breasted cows, we found 59 cows and heifers with clinical signs characteristic of myocardial dystrophy, which is 55.1 % of cows in this physiological group (Tables 5.1 and 5.2). Such a significant spread of the disease is due to the genetically inherited high productivity of animals, which contributes to the activation of cardiac activity and work at the limit of their capabilities [224, 225, 227].

Myocardial dystrophy was detected in 46.8 % of heifers, and among deep-calving cows the number of affected animals was 61.7 %. The most common ICD is among cows with more than one calving. However, among the animals we studied,

we found 13 deep-calving cows of the first lactation with clinical signs of MCD, which is obviously associated with the use of significant myocardial energy reserves at the beginning of the productive period.

Among the cows of the first lactation, we found 35.1 % of cases of myocardial dysfunction, 24.4 % in the second lactation, 18.9 % in the third lactation, and 19.6 % in the fourth and higher lactations (up to the 7th lactation) (Table 5.1). That is, 64.9 % of high-yielding cows with myocardial dystrophy have more than one calving.

Table 5.1

Prevalence of myocardial dystrophy in deep-calf cows depending on the number of lactations

Indexes	Number of lactations				Total
	first	2nd	3rd	4th and more	
Sick animals, total	13	9	7	8	37
%	35,1	24,4	18,9	19,6	100

Among dairy cows, we found 49.7 % of animals with myocardial dystrophy, since to maintain high milk production, there is a significant load on the heart muscle [4, 6, 217]. Among the group of newly calved cows (1-14 days after calving), MCD was detected in 50.6 % and in early lactation – in 49.1 %. This is due to the beginning of the lactation period, when the load on the heart increases several times for the formation of colostrum and then milk.

A clinical study of cows of three technological groups (deep-calving, newly calving and early lactation cows) revealed 51.7 % of animals with myocardial dystrophy and 8.3% with changes typical of hepatocardial syndrome (Fig. 5.1). If laboratory tests are taken into account, the prevalence of myocardial dystrophy is 48.1 % and hepatocardial syndrome 21.8 %.

The average milk yield of cows on farms is 5000-8000 kg of milk per lactation. The fat content of milk varies between farms and depends on both breed characteristics and cow feeding. The fat content of milk ranged from 3.4 to 4 %.

Highly productive cows reach their highest milk yields starting from 3-4 lactations, when the average daily milk yield reaches 20-30 litres or more.

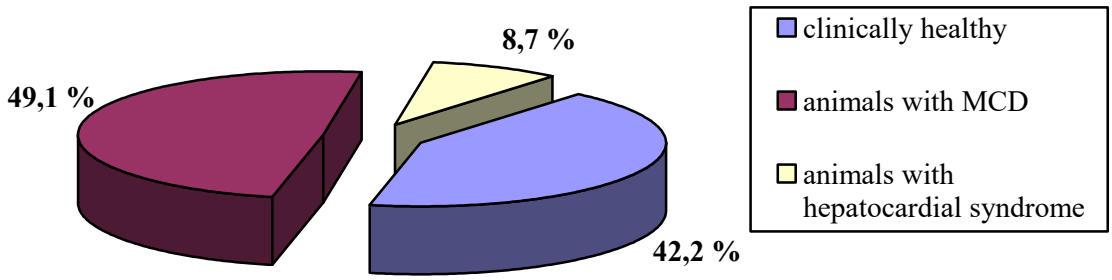

Figure 5.1. Prevalence of mycardial distrophy and hepatocardial syndrome among high-yield cows

In the studied clinically healthy deep-breasted cows, the average milk yield for the previous lactation was 4430.4±440.01 kg (2549.0-8319.0), while in cows with symptoms of myocardial dystrophy it was 5607.4±308.75 kg (3015.0-11106.0), and in 59.5 % of the diseased animals the milk yield exceeded 5 thousand kg of milk, while among clinically healthy cows such milk yields were observed in 47.1 %. Among the deep-calf cows with MCD, the highest number of cows had a milk yield of more than 6000 kg of milk in the previous lactation (40.6 %; Fig. 5.2). In this group, 77.3 % of animals were of the 2nd and more lactations

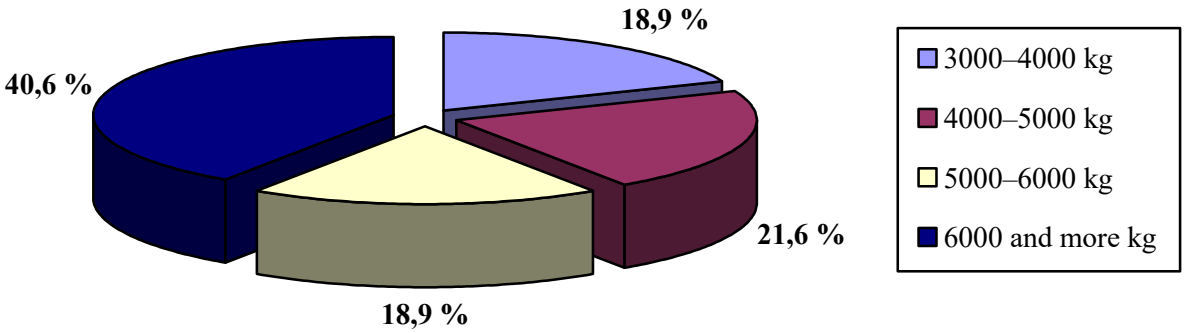

Figure 5.2. Prevalence of MCD among high-yielding deep-calf cows depending on lactation yield

Among clinically healthy dairy cows, the average daily productivity was 22.4±0.63 (17.4-28.3) kg of milk. In animals with myocardial dystrophy, milk production did

not differ (22.6±0.64; 16.0-34.0 kg). In 52.6 % of dairy cows with MCD, the average daily milk yield was from 20 to 25 kg of milk, and in 21.1 % – above 25 kg (Fig. 5.3).

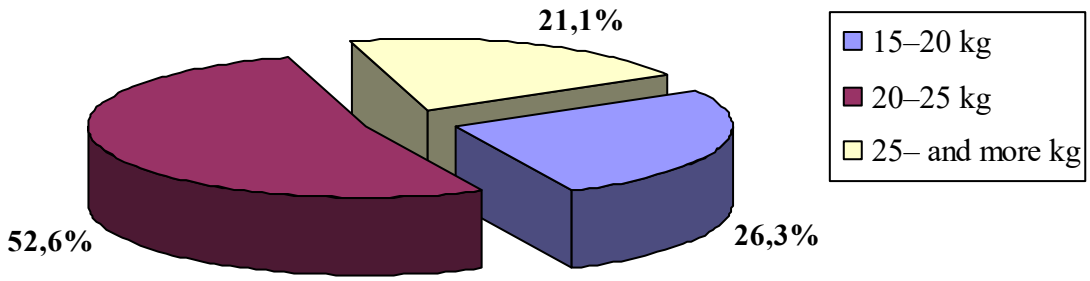

Figure 5.3. Prevalence of MCD among high-yielding dairy cows depending on daily productivity

The regrouping of cows from the milk production unit to the premises for deep-breasted animals and their transfer back to the dairy herd is a stressful factor that affects the condition of the heart and leads to dystrophic changes in its structure [227].

The average milk yield of dairy cows with myocardial dystrophy during the last lactation was 6214.5±445.58 kg (3050.0-10848.0), which was significantly higher ($p < 0.01$) than that of clinically healthy animals. Among the diseased dairy cows, 18 heads (81.8 %) were found to have a productivity of more than 5000 kg of milk during the last lactation. That is, the contributing factor is not the average daily productivity, but the productivity of cows per lactation, i.e. a longer period of time. Thus, high milk production of cows is one of the factors that can cause damage to the heart muscle.

One of the main links in the pathogenesis of MCD is intoxication due to metabolic disorders and physical stress of the myocardium to convert 75 % of the energy consumed from feed into milk, which is due to genetically inherited high milk production [4].

The cow housing systems in the farms where the monitoring studies were conducted have their own characteristics that affect the incidence of animal diseases.

Tethered housing implies that the livestock is constantly kept in a room during the stall period, where each animal has a separate place (stall) with a feeder and a drinking bowl. To restrict movement, each stall has a device (tether) for fixing the cow in it, which allows the animals to stand, lie down, eat feed, drink water, etc. In this case, almost all animal service operations take place on site in the stalls. Feed is delivered to the premises and distributed to the feeders, depending on the milk production of the cows. Water is supplied to waterers, fresh bedding is delivered and laid in the stalls, and excrement is systematically removed outside the premises. The cows are milked twice a day, and in between milking in sunny weather, they are allowed to walk. In summer, the heifers are kept in the exercise yards located next to the farm [224].

Along with the traditional indicators - productivity, fat and milk yield, fertility – in industrial conditions, great importance is attached to the following qualities of cows: suitability for group housing indoors, resistance to adverse environmental factors, etc.

The predominance of primary myocardial dystrophy is due to stress factors, namely the transfer of animals from the calving unit, where they were kept in large group untethered housing, to the drying unit with a tether, when exercise is reduced to a minimum. During this period, the ‘trained’ heart is not supported by peripheral muscles, whose movement increases haemodynamics and oxygen saturation of tissues. In the absence of exercise, dystrophic changes occur in the hypertrophied heart [228].

As for feeding, its first and most important condition is the complete satisfaction of all the animal's needs for energy necessary to ensure the functioning of the cardiovascular and respiratory systems, the synthesis of cellular proteins in the cow's body during its relative rest in comfortable conditions [228, 229].

World science and practice show with great conviction that the increase in milk production of cows is determined by rational feeding at a high level of organisation of animal husbandry technology [230]. The dry matter content of the feed determines the concentration of energy, nutrients and minerals in the rations, which allows to regulate the intensity, direction of feeding and productivity of cows. Evaluation of rations by feed units, without taking into account the dry matter content, does not give an idea of

the effectiveness of their use, especially in industrial milk production in the case of group rationing of cows [224].

It is known that due to a lack of protein in diets, digestibility and feed utilisation deteriorate, cow productivity decreases by 30-35 %, and product quality decreases, which leads to an increase in milk cost [231]. Sugar and starch are the optimal substrate for microorganisms that inhabit the fore stomachs of ruminants. The lack of these easily fermentable carbohydrates in the diet leads to a decrease in nutrient absorption, impaired carbohydrate and lipid metabolism, and the development of ketosis and acidosis [232]. A certain ratio of potassium, sodium and calcium ions is necessary for the physiological rhythm of cardiac activity [233].

In the winter-spring period, dry cows at OJSC Terezine are fed mainly with concentrated feed, which makes up 53.8 % of the total nutritional value in terms of metabolizable energy. The amount of roughage in the diet structure is low – 6.1 %, which causes an imbalance of nutrients in the rumen content, and the ratio of sugar to digestible protein is 1.11 : 1 (the norm is 1.0-1.1 : 1). The ratio of calcium to phosphorus is low – 1.41 : 1 (the norm is 1.6-1.8 : 1), which affects the absorption of these macronutrients in the body of cows.

In the winter-spring period, the diet of dry cows of LLC Agrofirma Glushky is dominated by juicy feed (67.3 % of the total nutritional value of the diet in terms of metabolizable energy), while roughage and concentrated feed accounted for 18.9 % and 13.8%, respectively. The cows are basically provided with nutrients, but there is a lack of some of them. For example, the ratio between easily fermentable carbohydrates and digestible protein is low (1.21 : 1, while the norm is 2.1-2.2 : 1), which has a negative impact on the rumen microflora. The ratio of calcium to phosphorus in the diet is 5.2 : 1. With this ratio, the body is unable to fully absorb them from feed, which can cause postpartum hypocalcaemia and osteodystrophy.

The diet of dry cows in the stall period lacks zinc, which reduces the activity of alkaline phosphatase and LDH, which include this trace element. The lack of cobalt and iron negatively affects haematopoietic function, iodine - the function of the thyroid gland, and disorders of these glands impair heart function [128, 225, 227]. Insufficient

intake of cholecalciferol in pregnant cows reduces the concentration of calcium in the body, which is necessary for cardiomyocyte contraction. Lack of carotene in cows leads to damage to the mucous membranes of the digestive, respiratory and skin organs.

Feeding of pregnant cows is very important, as part of the nutrients is spent on building the fetal body and its development [224]. Insufficient intake of calcium, zinc, cobalt, iodine, carotene, vitamin D causes the excretion of these elements from the cow's body, which are necessary for the normal functioning of the myocardium. After calving, this causes a significant increase in the prevalence of MCD and hepatocardial syndrome among newly calved cows (up to 66.2 %).

In the summer, the diet of dry cows at Terezine OJSC is dominated by juicy fodder, which accounts for 59.3 % of the total nutritional value of the diet in terms of metabolizable energy (mainly due to green maize). The amount of easily digestible carbohydrates (sugar and starch) is 3.9 times higher than the amount of digestible protein. 53.9 % of the digestible protein requirement is not enough to maintain protein metabolism in good condition. The lack of calcium and phosphorus in the diet leads to insufficient intake of these elements in the animal's body and, accordingly, to bone tissue and cardiomyocyte excitability disorders.

Deficiencies in trace elements such as zinc (92.7 % of the requirement), cobalt (55.2 %), iodine (60.6 %), as well as carotene (84.4 %) and vitamin D (19.0 %), cause osteogenesis and endocrine gland disorders, and reduce the biological activity of metal-containing enzymes.

The summer ration of cows in the drying shop of PE ‘Agrofirma Svitanok’ is unbalanced in almost all respects. It contains a sufficient amount of roughage (hay – 11.3 %, straw – 14.6 %). The diet contains a significant amount of concentrated feed – 37.6 %. The excess of easily fermentable carbohydrates over digestible protein (3.06 : 1) causes disruption of biochemical processes in the rumen. Indirectly, this effect also affects the cardiovascular system, as it can disrupt both energy and plastic metabolism in the myocardium (Table 5.6). The diet of dry cows contains a sufficient amount of calcium (101.2 % of the requirement), but the lack of phosphorus (calcium-phosphorus

ratio 2.25:1) reduces the absorption of these macronutrients in the intestine. Getting into the intercellular space, calcium ions cannot participate in the transmission of impulses to cardiomyocytes, which disrupts myocardial contractility [87, 231].

The dairy cows of LLC 'Agrofirma Glushky' are fed mainly with juicy and concentrated feed (62.1 and 35.7 % of nutritional value, respectively). The structure of the diet is mixed - concentrate, silage and haylage. The amount of digestible protein is significantly higher than the content of easily fermentable sugars in the diet (sugar + starch: digestible protein – 1.27 : 1, with a norm of 2.0-2.5 : 1). The amount of calcium and phosphorus is sufficient, and their ratio of 1.82 : 1 is optima.

The diet of dairy cows at Svitanok contains a large amount of juicy and concentrated feed, which is 51.9 % and 34.9 % of its total nutritional value, respectively. It is mixed in structure. The ratio between the sum of sugar and starch and digestible protein is low and amounts to 1.72:1, and the ratio between calcium and phosphorus is low for high-yielding cows – 1.67 : 1 (the norm is 1.8-2 : 1), which provokes calcium resorption from bones. The diet is deficient in manganese (87.7 % of the requirement), cobalt (68.0 %), iodine (69.6 %) and vitamin D (77.0 %).

Manganese deficiency causes impaired osteogenesis and haemoglobin formation. Cobalt is a component of vitamin B12, which stimulates the absorption of nitrogen in the body. Its deficiency causes hyperchromic anaemia, mucous membrane and skin disorders. Iodine is a component of thyroid hormones, and its deficiency disrupts its function, which causes changes in the cardiovascular system. Vitamin D deficiency leads to insufficient absorption of calcium and phosphorus from feed, which are the main components of the mineral part of bone tissue. [18, 209, 210, 232, 233].

The diet of dairy cows of LLC 'Agrofirma "Glushky" in summer is characterised by a low content of roughage (0.5 %) and a predominance of juicy feeds – 64.8 % of the total nutritional value of the diet. Lack of sugar and starch (76.1 and 75.2 %, respectively) with excessive protein feeding (sugar + starch to protein - 1.03:1) negatively affects both milk fat content and metabolic processes in the rumen. The oversaturation of the diet with calcium against the background of a reduced phosphorus content (Ca : P = 2.3 : 1) does not allow for optimal absorption of these

macronutrients, which may be the cause of their deficiency in body tissues.

The summer ration for dairy cows at OJSC Terezine is highly concentrated (49.4% of the total nutritional value), containing insufficient dry matter, sugar and fibre. The ratio of sugar and starch to protein is 2.1: 1, calcium to phosphorus – 1.35 : 1, which obviously impairs the absorption of macronutrients from feed.

The insufficient amount of trace elements in the diet: manganese (87.7% of the requirement), cobalt (68.0%) and iodine (30.1%) suppresses thyroid function. As a result, acidic glycosaminoglycans are deposited in the heart, lungs, kidneys, and serous cavities, which change the colloidal structure of their connective tissue, causing dystrophic changes.

Unbalanced feeding of deep-calving and dairy cows, impaired calcium to phosphorus ratio (normally 1.8-2 : 1) and insufficient absorption of energy and plastic materials necessary for the physiological functioning of the heart are among the factors that contribute to dystrophic changes in the myocardium.

In addition to feeding, heart disease can be the result of other diseases. Among the non-communicable diseases on farms, the most common are purulent necrotic lesions of the limbs, ketosis, and hepatodystrophy. We found 39 cows with limb lesions, 15 with signs of ketosis (the appearance of ketone bodies in the urine), which is 26.0 and 10 % of the total number of patients with myocardial dystrophy, respectively. 24 animals (8.3 %) with symptoms of hepatodystrophy were allocated to the group of cows with hepatocardial syndrome. Among the group of dairy cows with myocardial dystrophy, we found 38 animals (25.3 %) in which laboratory tests of blood serum revealed changes typical of hepatodystrophy (hyper- and dysproteinemia).

Among obstetric and gynaecological diseases, the most common are pathologies of childbirth, namely stillbirth, abortion, large-forced birth (5.3 % of the total number of sick animals), and endometritis (37.3 %). Many cows suffer from mastitis (36.0 %). Inflammation of the mammary gland is most common at Terezino, as the system of milking and keeping dairy cows has changed, which has affected the physiological state of the udder. These diseases cause the accumulation of toxic metabolic products in the body of highly productive cows, which enter the heart with the bloodstream. It is

known that 10 % of all circulating blood enters the coronary arteries, which supply the heart muscle with nutrients. Toxins enter the intercellular space and penetrate cardiomyocytes, disrupting their metabolism and energy. This leads to a decrease in the functional activity of the heart, which causes a violation of the cell structure.

Thus, myocardial dystrophy has a multi etiological nature, and its course is complicated by other diseases. The largest number of cows with myocardial dystrophy was found in the group of deep-calving and newly calving cows, respectively 55.1 and 50.6 % of the total number of animals in the group. Its development is influenced by the genetically determined high milk yield of cows; the most common ICD is in the case of milk yields of more than 5000 kg per lactation (59.5 % of sick cows in early lactation). In addition to heart disease (52.0 %), 15.1 % of high-yielding cows develop complex heart and liver disease under tethered conditions.

Nutrient imbalance in the diet: lack of easily digestible carbohydrates, excessive protein feeding, calcium intake disorders, lack of manganese, cobalt, iodine, carotene and vitamin D are factors that contribute to the development of myocardial dystrophy in high-yield cows. The main cause of MCD is intoxication, which develops as a result of metabolic disorders (ketosis, osteodystrophy, metabolic acidosis), liver structure and function, limb damage, stillbirths, abortions, large-forced births, endometritis and mastitis. Some of these diseases have common causes and pathogenetic mechanisms with ICD, such as ketosis and hepatodystrophy, i.e. multiple pathology. Others (endometritis, mastitis, purulent necrotic processes in the fingers), occurring simultaneously with ICD, complicate the pathological process in the myocardium, as there is a massive absorption of toxins and tissue decay products.

6. CLINICAL AND FUNCTIONAL DIAGNOSTICS OF MYOCARDIAL DYSTROPHY IN HIGH-YIELD COWS

In high-yielding cows, pathology of the liver, kidneys, fore stomach, and metabolic diseases are often recorded [18], which negatively affect the cardiovascular system [209]. To characterise the state of the cardiovascular system, we used general clinical (examination, palpation, auscultation) and special (measurement of ACP, ECG) research methods. Obviously, in different physiological periods (deep pregnancy, 1-14 days after delivery), functional changes will vary slightly. Clinical and functional diagnostics of high-yielding cows with myocardial dystrophy was carried out on 97 animals, of which 47 were deep-calving, 25 were newly calving and 25 were early lactation cows.

'Blood circulation is the main fundamental function of the body', which emphasises the importance of the cardiovascular system in the vital activity of the human and animal body. Diseases of the blood, respiratory, urinary, nervous, endocrine and digestive systems are always accompanied by impaired heart function [209].

During a clinical study of 97 highly productive cows with myocardial dystrophy, there was no edema in the underarm and limb area. Palpation of the thorax in the heart area revealed a weakening of the heartbeat in 44.3% of the animals.

In 47 high-yielding deep-breasted cows with MCD, we found the following changes in tones: amplification – in 20; weakening – in 15 and splitting – in 12 animals (Table 6.1).

In the group of newly degenerated diseased cows (25), 4 animals were found to have amplification, 10 - with weakening and splitting of tones, in one animal (4.0%) had a bifurcation of the first tone (Table 6.1).

Auscultation of the hearts of 25 early lactation cows with MCD revealed the following changes in tones: amplification – in 6; weakening – in 13 and splitting – in 6 animals.

Thus, the increase in tones, which is characteristic of the first stage of

myocardial dystrophy, was found in 30 animals, which is 30.9 % of all diseased cows, but the largest proportion of them – 42.6 % was among deep-calving cows. This indicates a deepening of the pathological process, when structural changes in cardiomyocytes and cells of the cardiac conduction system develop in the myocardium.

Table 6.1

Changes in heart tones in in high-yield cows of different technological groups

Changes of heart tones	Deep-calf cows		Sprawling cows		Early lactation cows	
	heads	%	heads	%	heads	%
Decrease of tones	15	31,9	10	40	13	52
Increase of tones	20	42,6	4	16	6	24
Tone splitting	12	25,5	10	40	6	24
Separation of the tone	–	–	1	4	–	–

One of the indicators of the cardiovascular system is the heart rate (HR) [18]. We found that in deep-bodied and newly degenerated cows with MCD, the heart rate averaged 80±1.05 and 79±1.19 beats/min (62-98 and 68-98 beats/min), which is significantly higher ($p < 0.001$) than that of clinically healthy cows of these technological groups (71±0.83 and 72±0.7 beats/min). Tachycardia (82-98 heartbeats per minute) was detected in 38.3 and 28.0 % of the diseased animals, respectively.

In cows with myocardial dystrophy of early lactation, the heart rate was 82±1.29 with fluctuations of 64-98 beats/min (in clinically healthy cows 72±0.74; $p < 0.001$) (Fig. 6.2). In 15 sick animals of this technological group (60.0%), the heart rate was higher than normal and ranged from 82 to 98 beats/min.

Thus, an increase in heart rate was diagnosed in 38.3 % of dry cows, 28.0 % of newly calved cows and 60.0 % of cows in the parturition group.

According to many authors [6, 8, 14, 24, 26, 119], heart failure causes changes in the lungs, which is manifested by an increase in respiratory rate. According to the results of our studies, the respiratory rate in cows with myocardial dystrophy was in the range of 14 to 30 breaths/min, i.e., it was the same as in clinically healthy cows (table 6.2).

Among the various methods proposed for the diagnosis of disorders of the cardiovascular system of animals, in veterinary practice, arterial blood pressure is often determined [92], which indirectly reflects the state of blood circulation in the body [93].

Table 6.2

Respiratory rate in high-yield cows with myocardial dystrophy (breath moves / min)

Group of cows		Deep-calf cows	Sprawling cows	Early lactation cows
Clinically healthy	Lim	16–28	14–28	16–30
	M±m	22±0,49	22±0,7	23±0,74
Sick with MCD	Lim	16–30	16–30	14–30
	M±m	23±0,55	22±0,73	22±0,84
	p <	0,1	0,1	0,1

Note. p < – compared to clinically healthy animals

The results of tonometry indicate that in high-yielding deep-calf cows with myocardial dystrophy, systolic and pulse blood pressure were 113.6±2.03 (90.0-140.0) and 67.0±2.03 (40.0-100.0) mm Hg, respectively, which is significantly lower ($p < 0.01$) than in clinically healthy animals (Table 6.3). Diastolic blood pressure was 46.6±1.3 mm Hg with fluctuations from 30.0 to 80.0 mm Hg and tended to increase compared to clinically healthy cows (in healthy cows – 46.0±1.55 mm Hg). A decrease in SBP against the norm (90.0 mm Hg) was detected in two cows (4.3 %). At the lower limit of the norm (100.0 mm Hg), this indicator was in 29.8 % of animals, indicating a decrease in myocardial contraction force. An increase in DBP was found in 19.1 %.

Among the newly degenerated cows with myocardial dystrophy, SBP and DBP were, respectively, 109.6±3.13 (90.0-140.0) and 62.4±3.43 mm Hg (40.0-90.0), i.e., significantly lower ($p < 0.01$) compared to clinically healthy animals. A decrease in systolic and pulse ACP was detected in 12.0 and 20.0 % of the diseased animals, respectively. DBP averaged 47.2±1.69 mm Hg (30.0-60.0), and compared to clinically healthy cows, it tended to increase (Table 6.3).

In the group of sick cows of early lactation, systolic, diastolic and pulse blood

pressure were 106.8±2.87 (90.0-41.6±1.6 (30.0-60.0) and 65.2±3.17 (40.0-100.0) mm Hg. We found a significant decrease in them compared to clinically healthy animals ($p2 < 0.001$; $p2 < 0.05$; $p2 < 0.05$) (see Table 6.3). A decrease in SBP was detected in 24.0% of diseased cows. An increase and decrease in the indicators of PAP were found in 4.0 and 8.0 % of diseased animals, respectively.

Table 6.3

ABP values in high-yielding cows with myocardial dystrophy

Clinical status of animals	Arterial blood preasure, mm Hg		
	SBP	DBP	PBP
Deep-calf cows			
Clinically healthy	121,0±1,67	46,0±1,55	74,0±1,55
Sick with MCD p <	113,6±2,03 0,01	46,6±1,3 0,1	67,0±2,03 0,01
Sprawling cows			
Clinically healthy	120,0±2,13	47,0±1,88	73,0±2,77
Sick with MCD p <	109,6±3,13 0,01	47,2±1,69 0,1	62,4±3,43 0,01
Early lactation cows			
Clinically healthy	119,0±1,94	46,0±1,29	73,0±2,37
Sick with MCD	106,8±2,87 0,001	41,6±1,6 0,05	65,2±3,17 0,05

Note. p < – compared to clinically healthy animals

Thus, clinical studies have shown that myocardial dystrophy in high-yielding cows is characterised by tachycardia, weakening of the heartbeat, changes in heart sounds, and a decrease in systolic and pulse blood pressure.

The study of myocardial electrical activity for the diagnosis of myocardial dystrophy is very important. This method successfully resolves issues related to the diagnosis of rhythm disturbances and focal myocardial lesions. [234]. Electrocardiographic examination was performed in frontal leads according to M.P. Roschevsky [213].

During a clinical study of sick cows with ECG recording, the number of heartbeats was 82±1.32 (70-96) beats/min, which is significantly higher ($p < 0.001$) compared to clinically healthy animals (71.0±1.19 beats/min). Tachycardia (82-96 beats/min) was observed in 54.8 % of the studied animals.

Analysis of the ECG of cows with myocardial dystrophy showed that their cardiac cycle was rhythmic, since the difference between the maximum and minimum duration of individual intervals (R-R) did not exceed 10 % (7.8 % on average). The rhythm is sinus, i.e. the alternation of the teeth is correct.

The electrocardiogram of high-yielding cows with myocardial dystrophy in the first lead was characterised by negative P waves in 15.4 % and T waves in 69.2 % of cases, while in clinically healthy cows - in 11.1 and 77.8 %, respectively (Fig. 6.1).

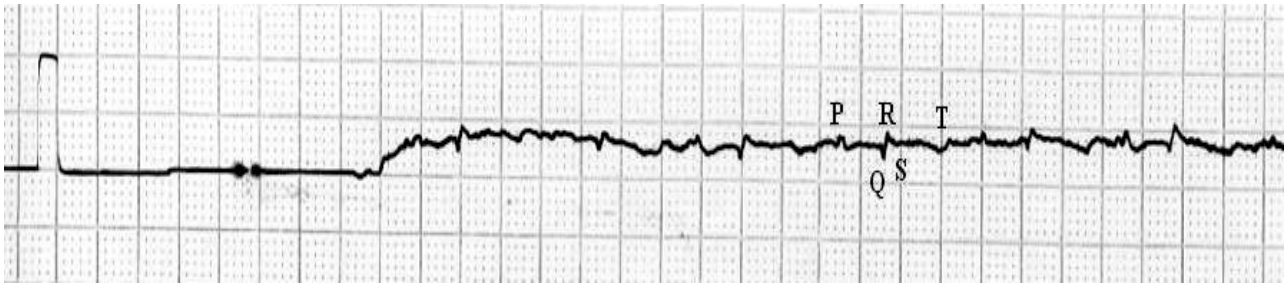

Figure 6.1. Electrocardiogram in the first lead of a cow with myocardial dystrophy

The voltages of the P and T waves tended to decrease compared to clinically healthy animals and were 0.11±0.017 (0.03-0.23) and 0.13±0.026 mV (0.07-0.37), respectively. The Q wave voltage was expressed only in 23.1% of animals, and its mean value in the group was 0.02±0.01 mV with fluctuations from 0.02 to 0.07 mV. The amplitude of the R wave was 0.03-0.47 mV (0.26±0.009) and tended to decrease compared to clinically healthy animals (0.27±0.047 mV). The S wave significantly ($p<0.001$) decreased to 0.16±0.07 mV (0.03-0.77), compared with 0.03±0.004 mV in clinically healthy animals. The voltage of the T wave was 0.13±0.026 mV with fluctuations from 0.07 to 0.37 mV (in clinically healthy cows - 0.14±0.022 mV; Fig. 6.2).

In the second frontal lead, the voltages of the P and S waves had an amplitude of 0.17-0.3 mV (0.23±0.011) and 0.2-1.87 mV (0.81±0.145), respectively, and were characterised by an upward trend compared to clinically healthy animals (0.19±0.023 and 0.62±0.11 mV).

The voltage of the R tooth was 0.25±0.069 (0.03-0.83) mV and tended to decrease compared to clinically healthy animals (0.27±0.073 mV). The T tooth had an average voltage of 0.54±0.072 mV with fluctuations of 0.17-1.0 mV (Figs. 6.1 and 6.2). In 18.8 % of the studied animals, a negative T wave was detected in the second lead, indicating a violation of biochemical processes in the myocardium (Fig. 6.3).

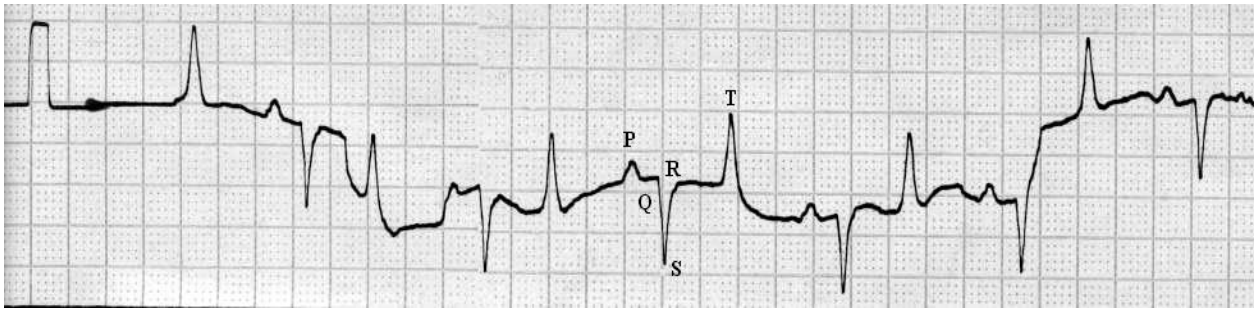

Figure 6.2. Electrocardiogram of a cow with myocardial dystrophy in the second lead

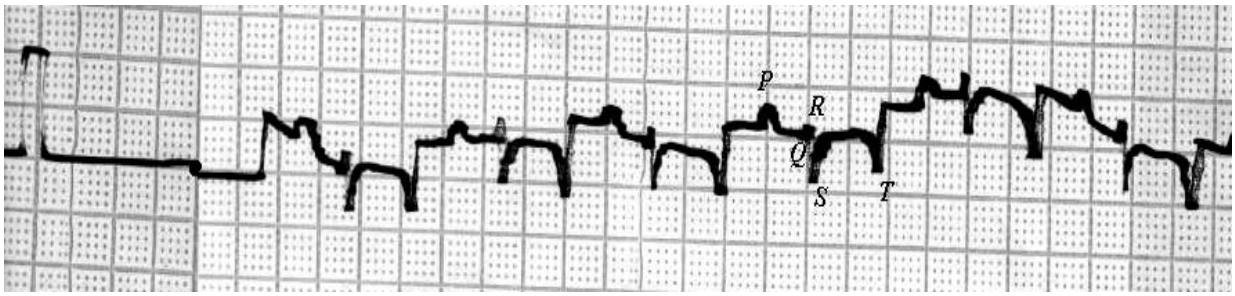

Figure 6.3. Negative tooth T in the second lead

The third frontal lead in cows with myocardial dystrophy was characterised by an increase in the voltages of the P, S, T and a decrease in Q and R, compared with clinically healthy animals (Fig. 6.4).

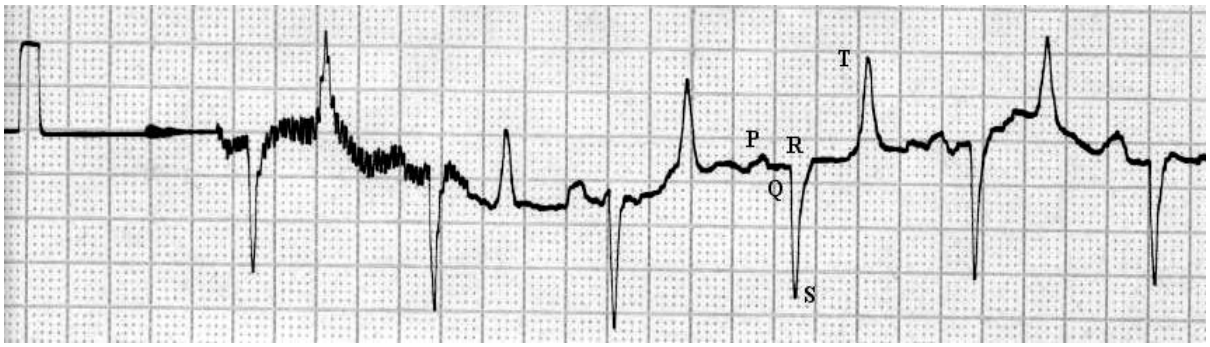

Figure 6.4. Electrocardiogram of a cow with myocardial dystrophy in the third lead

In 18.8 % of cows with MCD, a negative T wave was detected in all leads, indicating significant damage to cardiomyocytes in these animals, since the repolarisation processes in this case are in the opposite direction.

During the analysis of ECG parameters, we found that the duration of the T-R interval in cows with myocardial dystrophy (deep-calving and dairy herd) was significantly reduced ($p < 0.001$; $p < 0.05$) compared to clinically healthy cows (see Tables 6.4 and 6.5). This, in our opinion, is evidence that the heart muscle rests less in sick animals. Violation of the cardiac cycle affects the biochemical composition of cardiomyocytes, which is manifested by the release of its constituent structures: cardiotroponins, myoglobin, cytoplasmic enzymes - CC, LDH, and ACAT. Against this background, heart failure develops and, as a result, myocardial dystrophy.

In the analysis of electrocardiograms, the values of atrioventricular conduction and systolic index are widely used, which characterise the cardiac cycle in dynamics and the state of the conduction system [97, 211, 213].

If the absolute duration of the PQ interval did not change in deep-calving and dairy cows with MCD, the relative atrioventricular conduction increased and amounted to 21.8±1.74 % (13.8-31.2) and 25.3±0.97 % (20.0-35.7), respectively ($p < 0.01$; Figs. 6.8; 6.9) against 19.1±0.85 and 19.8±1.35 % in clinically healthy cows. This indicates damage to the myocardial conduction system, resulting in reduced impulse transmission from the sinus node to the ventricles.

The systolic index in deep-calving cows with clinical signs of myocardial dystrophy was 42.3±1.31 % (37.7-50.8) and significantly increased ($p < 0.01$) compared to clinically healthy animals (34.8±2.47 %). In the group of dairy herd animals, the average value of systolic index was 43.1±1.45 % with fluctuations from 33.0 to 59.5 % and tended to increase compared to clinically healthy animals (39.5±2.17 %).

Such changes in the systolic index, compared with clinically healthy animals, indicate impaired impulse conduction in the ventricles and myocardial cell depletion, since the heart muscle does not have sufficient time to rest. During systole, cardiomyocytes do not fully repolarise and, as a result, develop dystrophy.

Consequently, myocardial dystrophy is characterised by a decrease in the duration of the R-R cardiac cycle due to a shorter T-P diastole, the appearance of a negative T wave in all leads, and cardiac cycle disturbances, which are manifested by an increase in relative atrioventricular conduction and the proportion of Q-T electrical systole in the cardiac cycle. Such changes are typical for myocardial dystrophy, as they characterise changes in the function and condition of cardiomyocytes.

Thus, to diagnose myocardial dystrophy in high-yielding cows, it is necessary to take into account the weakening of the heartbeat, changes in the tones of weakening, strengthening, splitting and sometimes bifurcation), tachycardia (expressed in 41.2 % of sick animals), and a decrease in systolic blood pressure (less than 100 mm Hg). During the electrocardiographic examination, in 18.8 % of the diseased animals, the T wave was negative in all leads, the cardiac cycle duration (R-R) decreased in 58.1 % of the animals due to a decrease in diastole (51.5 %), increased relative atrioventricular conductivity in 50.0 % of dairy cows and systolic index in 45.5 % of deep-calf animals.

7. ENZYME DIAGNOSTICS OF MYOCARDIAL DYSTROPHY IN HIGH-YIELD COWS

The organ-specificity of isoenzyme diagnostics of heart disease is based on the difference in the ratio of isoenzymes in individual organs and, consequently, in the blood serum in case of their damage [210]. Such markers in the case of heart disease are the activity of cardiac-specific isoenzymes, in particular creatine kinase (CK-MB) [222].

Creatine kinase (CK) is mainly found in muscle tissue [115]. The idea that creatine kinase transfers energy from the mitochondria to the sites of its use in the muscle cell originated from the studies of Bessman, Gudjarnason and others [238-240]. This concept has been experimentally confirmed in studies on the synthesis of creatine phosphate in cardiac mitochondria and in studies of the localisation and functional role of creatine kinase isozymes in myocardial cells [121, 241-243].

We found that the activity of total creatine phosphokinase (CK-NAC) in the serum of 23 high-yielding deep-calf and 20 early lactation cows with myocardial dystrophy was at the level of 68.2 ± 12.09 U/l (19.3-254.5) and 75.1 ± 6.67 U/l (22.0-147.5), respectively, which was significantly ($p < 0.01$; $p < 0.001$) higher than that of clinically healthy animals (Table 7.1). Hyperfermentation of total creatine kinase (more than 80 U/l) was detected in 34.8 % of sick deep-calf cows and 54.6 % of animals in early lactation.

In the serum of 15 newly tumoured animals with MCD, we found the activity of CK-NAC at the level of 79.6±13.7 U/l (44.0-216.0), which tended to increase compared to clinically healthy animals (Table 7.1). Hyperenzymemia of total creatine kinase was detected in 33.3 % of diseased cows.

The activity of the cardiac isoenzyme CK in pregnant cows with myocardial dystrophy averaged 30.6±5.05 U/l with fluctuations in the range of 5.5-112.8 U/l, which is significantly higher than in clinically healthy animals ($p < 0.001$; Table 7.1). Hyperfermentation of CK-MB was detected in 69.6 % of sick animals of this technological group.

In the group of newly degenerated cows with clinical signs of MCD, the activity of the cardiac fraction of creatine kinase averaged 33.8±7.69 U/l (5.5-121.1) and was significantly higher than that of clinically healthy animals ($p < 0.001$; Table 7.1). In 73.3 % of diseased cows, an increase in the activity of the isozyme was noted.

Table 7.1

Creatine kinase activity in blood serum of high-yielding cows

Clinical condition of cows	KK-NAC, Un/l	KK-MB, Un/l	KK-MB / KK-NAC, %
Deep-calf cows			
Clinically healthy	35,1±4,35	6,0±0,84	17,1±9,48
Cows with myocardial dystrophy p <	68,2±12,09 0,01	30,6±5,05 0,01	44,9±3,56 0,001
Sprawling cows			
Clinically healthy	53,2±10,43	10,2±2,19	19,2±4,36
Cows with myocardial dystrophyp <	79,6±13,7 0,1	33,8±7,69 0,001	42,5±5,13 0,001
Early lactation cows **s**			
Clinically healthy	41,9±3,86	9,8±1,82	23,4±3,2
Cows with myocardial dystrophyp <	75,1±6,67 0,01	37,2±3,99 0,001	49,5±3,56 0,001

Note. p < – compared to clinically healthy animals

In the blood serum of early lactation cows with clinical signs of myocardial dystrophy, the activity of CK-MB was in the range of 13.8-52.3 U/l with an average value of 37.2±3.99 U/l, which was significantly higher ($p < 0.001$) than in clinically healthy animals. An increase in the activity of myocardial isoenzyme was detected in 93.7 % of diseased cows.

The ratio of CK-MB activity to total CK in deep-calf cows with myocardial dystrophy averaged 44.9±3.56 % with fluctuations of 17.3-81.8 %, which is significantly higher than in clinically healthy animals ($p < 0.001$). In 73.9 % of cows, an increase in the ratio of CC-MB/CC-NAC was detected.

In the blood serum of highly productive newly degenerated cows with clinical signs of MCD, the proportion of cardiac isoenzyme in the structure of total CK

activity averaged 42.5±5.13 % (18.5-94.0), which is significantly higher than in clinically healthy animals ($p < 0.001$; see Table 8.1). An increase in this indicator was detected in 53.3 % of the diseased animals.

The proportion of myocardial isoenzyme in the total activity of CK-NAC in patients with MCD in early lactation cows averaged 49.5±3.56 %, with fluctuations of 22.5-78.7, which is significantly higher ($p<0.001$) than in clinically healthy animals. An increase in the ratio of CC-MB to total CC was detected in 65 % of diseased cows.

We found that in 29.4 % of cows of different technological groups, in which no clinical changes in heart function were detected, namely, weakening of the heartbeat, changes in tones during auscultation, tachycardia and a decrease in systolic ACP against the norm, the activity of total creatine kinase and its isoenzyme exceeded 80.0 and 20.0 U/l, respectively, which is considered the upper limit of normal. Thus, the activity of CK-NAC in animals averaged 60.7±10.09 U/l (24.8-129.3), and CK-MB - 30.8±4.99 U/l (13.8-57.8), which is significantly higher than in clinically healthy animals ($p < 0.001$). Hyperfermentation was detected in 13.6 and 17.0% of animals, respectively. The ratio of cardiac-specific isoenzyme to total creatine kinase activity in these cows averaged 51.4±3.5 % (38.5-66.7), which is significantly higher than in clinically healthy animals ($p<0.001$). An increase in the ratio of CK-MB/CK-NAC was detected in 92.9 % of cows, indicating the presence of destructive changes in the myocardium that cannot be detected by clinical methods (table 7.2).

Table 7.2

Serum creatine kinase activity in high-yielding cows with subclinical myocardial dystrophy

Clinical condition of cows	KK-NAC, Un/l	KK-MB, Un/l	$\frac{\text{KK-MB}}{\text{KK-NAC}}$, %
Clinically healthy	43,1±4,82	8,8±1,01	20,4±2,0
Cows with subclinical myocardial dystrophy	60,7±10,09 0,1	30,8±4,99 0,001	51,4±3,5 0,001

Note. p < – compared to clinically healthy animals

Thus, in high-yielding cows with the development of myocardial dystrophy, the activity of total creatine kinase increases at the expense of the cardiac isoenzyme.

Thus, the determination of total CK activity, its cardiac isoenzyme and the percentage of CK-MB/KK-NAC are highly informative tests for the early diagnosis of myocardial dystrophy in high-yield cows.

Lactate dehydrogenase (LDH) is a cytosolic enzyme that catalyses the oxidation of L-lactate to pyruvic acid. The enzyme is localised in cells of various organs, which reduces its diagnostic value when determining total activity. However, the isoenzyme forms of this enzyme (LDH1- LDH5) have high organ specificity. Thus, the LDH1 fraction is localised mainly in cardiomyocytes [128, 132, 222].

We found that the activity of total LDH in high-yielding deep-body and newly bred cows with myocardial dystrophy was 350.3±11.06 U/l (214.0-507.0) and 363.6±12.5 U/l (111.0-485.0) and tended to increase compared to clinically healthy animals (Table 7.3). Hyperfermentation of total lactate dehydrogenase was detected in 15.9 and 8.0 % of sick animals of the respective technological groups.

Table 7.3

Lactate dehydrogenase activity in the blood serum of high-yielding cows

Clinical status of cows	LDH U/l	LDH1, U/l	$\frac{LDH_1}{LDH}$, %
Deep-calf cows			
Clinically healthy	345,9±15,21	160,1±9,32	46,3±1,78
Sick with MCD p <	350,3±11,06 0,1	234,5±10,06 0,01	66,1±2,07 0,001
Sprawling cows			
Clinically healthy	339,1±14,23	165,4±12,29	48,8±2,5
Sick with MCD p <	363,6±12,5 0,1	253,6±11,66 0,001	69,7±2,06 0,001
Early lactation cows			
Clinically healthy	327,6±15,0	150,2±10,11	45,8±1,56
Sick with MCD	389,7±10,51 0,001	243,6±10,2 0,001	62,5±2,34 0,001

Note. p < – compared to clinically healthy animals

The activity of total lactate dehydrogenase in the blood serum of early lactation cows with clinical signs of myocardial dystrophy averaged 389.7±10.51 U/l with fluctuations of 288.0-498.0 U/l, which is significantly higher ($p < 0.001$) than that of clinically healthy animals (Table 7.3). Hyperfermentation of total LDH was diagnosed in 12.0% of diseased cows.

The activity of the cardiac isoenzyme LDH in the blood serum of deeply pregnant cows with MCD was on average 234.5±10.06 U/l (111.0-485.0), which is significantly higher ($p<0.01$) than that of clinically healthy animals (Table 7.3). An increase in the activity of the isozyme was detected in 72.3 % of the diseased animals.

In the group of newly degenerated and early lactation cows with myocardial dystrophy, the activity of the myocardial fraction of LDH was in the range of 178.0-478.0 and 130.0-313.0 U/l with mean values of 253.6±11.66 and 243.6±10.2 U/l, which is significantly ($p < 0.001$; $p < 0.001$) higher than in clinically healthy animals. Hyperfermentation of LDH1 was found in 84.0% of diseased cows of each technological group.

The proportion of cardiac isoenzyme (LDH1) in the structure of total lactate dehydrogenase activity in the blood serum of deep-calf cows with MCD was 66.1±2.07 % (34.3-95.7), which was significantly higher than in clinically healthy animals ($p < 0.001$; Table 7.3). An increase in the ratio of LDH1 to total lactate dehydrogenase was detected in 85.1 % of diseased cows.

In newly bred cows and animals of early lactation with MCD, the ratio of LDH1/TLD was 69.7±2.06 % and 62.5±2.34 % with fluctuations in the range of 53.1-94.1 and 34.1-83.7, which is significantly higher ($p < 0.001$) than in clinically healthy animals. An increase in the percentage of LDH1in the structure of total lactate dehydrogenase activity was found in 72.0 and 96.0 % of diseased cows, respectively.

We found 25.9 % of clinically healthy cows with higher than normal activity of LDH and its cardiac isoenzyme LDH1. Thus, the activity of total lactate dehydrogenase averaged 328.8±16.68 U/l (163.0-530.0), LDH1 – 202.5±12.95 U/l

(106.0-391.0) ($p < 0.001$) and LDH1/LDH – 61.7±1.84 % ($p < 0.001$, compared to clinically healthy cows) (Table 7.4). Hyperenzymemia was detected in 6.7 and 36.7 %, respectively, and an increase in the proportion of LDH1 in the activity of total LDH in 86.7 % of animals, indicating the high informative value of this test for the early diagnosis of myocardial dystrophy.

Table 7.4

Activity of lactate dehydrogenase in the blood serum of highly productive cows with subclinical myocardial dystrophy

Clinical status of animals	LDH, U/l	LDH1, U/l	$\frac{\text{LDH1}}{\text{LDH}}$, %
Clinically healthy	331,8±9,86	155,7±4,03	46,9±0,72
Cows with sublinical status of myicardil dystrophy	328,8±16,68	202,5±12,95	61,7±1,84
p <	0,1	0,001	0,001

Note. p< – compared to clinically healthy animals

According to the literature [113, 116, 119, 125, 128, 132], an increase in lactate dehydrogenase activity is a later diagnostic test of myocardial damage, unlike CC. However, in high-yielding cows with myocardial dystrophy, hyperfermentation of the cardiac fraction of LDH was detected in at least 72.3 % of animals, i.e. this test is quite informative.

When determining the activity of total lactate dehydrogenase and its cardiac isoenzyme, it is necessary to take into account the proportion of LDH1/LDH, which almost unmistakably indicates myocardial damage in high-yield cows, regardless of their physiological state and the presence of clinical signs of heart failure.

The increase in the activity of cardiac-specific isoenzymes CK and LDH, as well as the proportion of CK-MB and LDH1 in their total activity, indicates the presence of cardiomyocyte dystrophy in highly productive cows of different technological groups.

The above data indicate that in order to diagnose myocardial dystrophy in high-yielding cows, it is necessary to determine the activity of cardiac isoenzymes lactate dehydrogenase and creatine kinase, as well as to calculate their ratio to the

total enzyme activity. Table 7.5 shows that the determination of CK-MB activity has the highest informative value in the group of early lactation cows – 93.7%, while the informative value of CK-MB/CK-NAC in late lactation animals is 73.9 %.

Table 7.5

Informativeness of CK-MB and LDH1 for the diagnosis of myocardial dystrophy (in per cent)

Group of cows	CK-MB	$\frac{\text{CK-MB}}{\text{CK-NAC}}$	LDH1, U/l	$\frac{\text{LDH1}}{\text{LDH}}$, %
Deep-calf	69,6	73,9	72,3	85,1
Sprawling	73,3	53,3	84,0	72,0
Early lactation	93,7	65,0	84,0	96,0

The informativeness of LDH1 and LDH1/LDH is highest in the group of early lactation cows, which is 84.0 and 96.0 %, respectively. This test for the diagnosis of MCD in high-yield cows has an informative value of at least 72.0 %, while CC-MV and CC-MV/CC-NAC have an informative value of 53.3 %.

The use of early biochemical tests allows to diagnose heart disease at early, subclinical stages of pathology development, to study compensatory and adaptive reactions of heart disease development for effective treatment of the disease. For the purpose of diagnosing subclinical myocardial dystrophy in high-yield cows, the determination of LDH1 activity and the LDH1/LDH ratio is more informative than the activity of the cardiac fraction of CK and its ratio to total creatine kinase.

8. HEPATOCARDIAL SYNDROME IN HIGHLY PRODUCTIVE COWS

Clinical and experimental studies of liver disease in cattle have shown that the pathological process causes changes in the cardiovascular system. Changes in the functional state of the cardiovascular system are caused by cholestasis and cholemia, impaired detoxification and protein synthesis functions of the liver, which supplies the myocardium with materials used by it as energy, in particular, carbohydrate and lipid metabolism products. It is known that functional heart failure disrupts blood circulation in the liver, which weakens the reparative processes in the liver. This creates a 'vicious circle' that exacerbates the pathological process in both organs [235].

Based on the results of a clinical study of highly productive cows and the determination of biochemical blood parameters characterising the functional state of the myocardium and hepatocytes, signs characteristic of heart and liver pathology, called 'hepatocardial syndrome', were identified.

According to the results of clinical examination and laboratory blood analysis, we identified 62 cows (26 newly calved animals and 36 in early lactation) with signs of hepatocardial syndrome, which is 21.8% of the number of animals studied. The prevalence of the disease is caused by insufficient intake of energy and plastic materials necessary for the functioning of the myocardium and stall housing of cows.

All diseased cows were of average or above average weight, and one newly bred animal was below average. No edema was observed in the areas of the underarms, distal limbs, and submandibular space. The heartbeat was rhythmic, weakened, localised, and the heart area was not painful. Auscultation of the heart revealed changes in tones, which is a sign of cardiac dysfunction. Thus, in 33.9 % of cows with hepatocardial syndrome, we observed an increase in tones, in 37.8 % – a decrease and in 28.3 % - a split of one of the heart sounds.

Among the newly deceased animals, the increase in tones was detected in 7, the decrease in 9, and the split in 10 cows, which is 26.9 %, 34.6% and 38.5 %, respectively. In one animal (3.8 %), both an increase in the second and splitting of the

first tones and tachycardia (98 beats/min) were detected.

In early lactation cows, auscultation of the heart area revealed the following changes: increased tones – in 33.3 %, weakening – in 47.2 % and splitting – in 19.5 % of animals.

In the case of simultaneous heart and liver disease, it is important to determine the heart rate. It is known that, depending on their nature (parenchymal or purulent hepatitis, hepatodystrophy, cirrhosis) and the stage of development of pathologies, bradycardia and splitting of the second tone or tachycardia and weakening of the heart sounds are diagnosed [236].

In newly degenerated animals with signs of hepatocardial syndrome, 80±1.88 heartbeats per 1 min were found, ranging from 52 to 98, which is significantly higher ($p < 0.01$) than in clinically healthy cows of this technological group. Tachycardia (82-98 beats/min), which is one of the cardiac lesions, was found in 42.3 % of the diseased animals. In one cow, bradycardia (52 beats/min) was observed, which was apparently caused by a delay in the excretion of bile acids from the liver [236].

In sick cows of early lactation, the heart rate was 82±1.42 beats/min (68-98), which is significantly higher ($p < 0.01$) than in clinically healthy cows. An increase in heart rate was noted in 52.7 % of sick cows with hepatocardial syndrome, bradycardia was not recorded.

The respiratory system is closely related to the activity of the heart. In the case of heart failure, compensatory phenomena occur in the lungs – tachypnoea [20]. However, the respiratory rate in newly calved and early lactation cows with clinical signs of hepatocardial syndrome did not differ from the values of clinically healthy animals and was 23±1.18 (18-30) and 24±0.64 (16-36) respiratory movements per 1 min, respectively. Tachypnoea was detected in only one (2.8 %) cow in early lactation.

Clinical examination of the liver in 38.7 % of high-yielding cows revealed an increase in its percussion border in the 12th intercostal space by 3-8 cm, in the 11th - 3-6 cm. There were no changes in the colour of the mucous membranes in diseased animals.

The determination of arterial blood pressure is an informative method for the early diagnosis of cardiovascular dysfunction in animals [92]. Among the newly degenerated animals, systolic and pulse blood pressure were at the level of 113.3±2.79 (90.0-140.0) and 64.8±2.55 mm Hg (40.0-90.0), which is significantly lower ($p < 0.05$; $p < 0.01$) than in clinically healthy cows (Fig. 8.4). We found these changes in 33.3 and 41.7 % of sick cows of this technological group. In one animal (8.3 %), an increase in SBP up to 80 mm Hg was observed.

The values of systolic, diastolic and pulse blood pressure in early lactation cows with hepatocardial syndrome were reduced by 4.5 %, 0.9 % and 6.9 %, respectively, compared to clinically healthy cows. Lower than normal values of SBP were found in 25.0 %, and of PAP – in 33.3 % of the diseased animals. An increase in systolic, diastolic and pulse arterial blood pressure was detected in 16.7, 25.0 and 8.3 % of cows with clinical symptoms of liver and heart damage, respectively.

Thus, combined heart and liver pathology develops when feeding and housing conditions are not appropriate. A clinical study of highly productive dairy cows with hepatocardial syndrome revealed tachycardia (up to 98 beats/min), changes in tones and blood pressure, and a shift in the percussion boundaries of the liver.

During a clinical study of sick cows with ECG recording, the number of heartbeats was 82±3.72 beats/min (70-98), which is significantly higher ($p<0.01$) than in clinically healthy animals. Tachycardia (82-98 beats/min) was observed in 37.5 % of the studied animals.

The analysis of the ECG of cows with hepatocardial syndrome revealed that the cardiac cycle was rhythmic, since the maximum fluctuations in the duration of individual intervals (R-R) did not exceed 10 % (9.1 %). The rhythm is sinus, the alternation of the teeth is sequential.

The electrocardiogram of high-yielding cows with hepatocardial syndrome in the first lead is characterised by negative P and T waves in 75 % of cases (Fig. 8.1). Compared to clinically healthy animals, the voltages of the P and T waves were significantly increased ($p < 0.05$), which was 0.09 ± 0.013 mV (0.07-0.17; $p < 0.05$) and 0.09 ± 0.0013 mV (0.03-0.13; $p < 0.05$), respectively. The Q wave is expressed

only in 50 % of animals with a value of 0.03 mV. The amplitude of the negative S wave tends to increase and amounts to 0.04±0.009 mV with a range from 0.03 to 0.1 mV (Fig. 8.2).

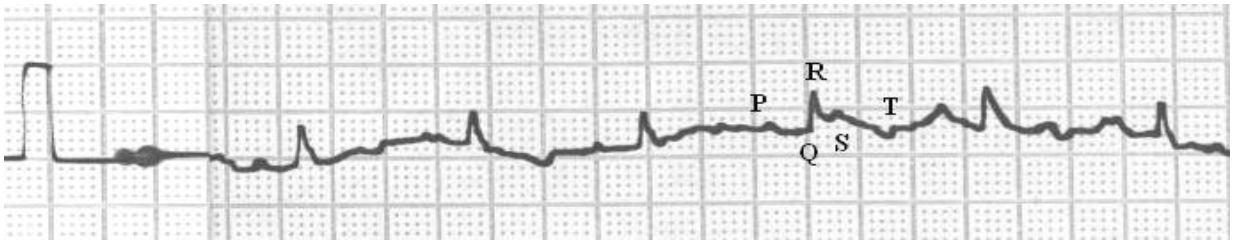

Figure 8.1. Electrocardiogram of a cow with hepatocardial syndrome in the first lead

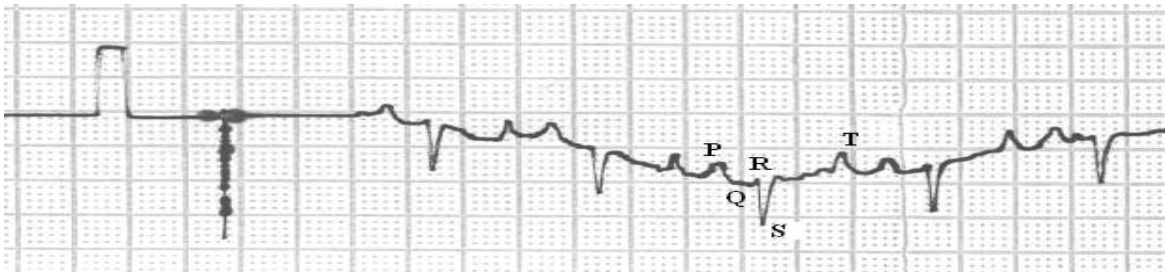

Figure 8.2. Electrocardiogram of a cow with hepatocardial syndrome in the second lead

In the second frontal lead, the voltages of the P and S waves are increased compared to clinically healthy animals and have an amplitude of 0.21±0.013 mV (0.17-0.23) and 0.79±0.102 mV (0.4-1.17), respectively. The voltage of the R tooth was reduced to 0.16±0.08 mV (0.03-0.63). The T tooth has an average voltage of 0.44±0.097 mV with fluctuations of 0.17-0.9 mV.

The third frontal lead in cows with multiple pathology is characterised by an increase in the voltages of the P, S and T teeth compared to clinically healthy animals, and the expression of the Q tooth in 12.5 % of animals (Fig. 8.3).

On the electrocardiogram, with the simultaneous occurrence of heart and liver pathologies, the duration of the cardiac cycle R-R ($p < 0.01$) and diastole T-P ($p < 0.001$) significantly decreases compared to that of clinically healthy animals. A decrease in systole duration leads to cardiac muscle fatigue and, as a result, to the development of heart failure.

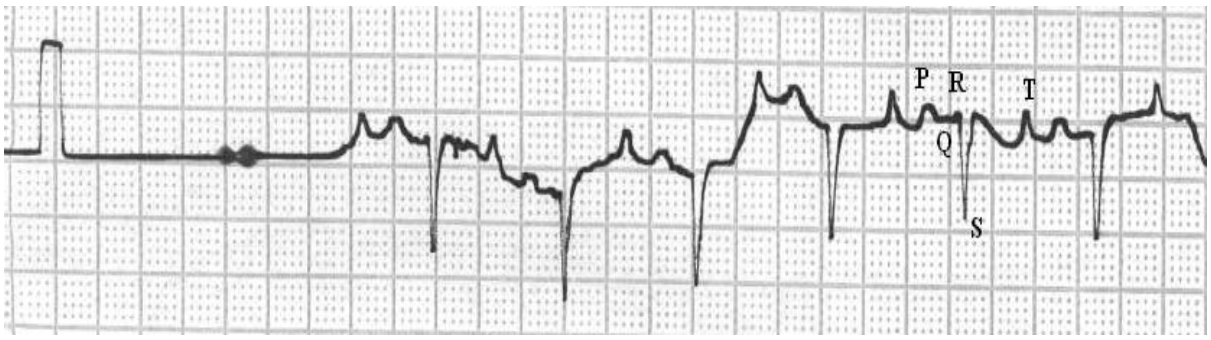

Figure 8.3. Electrocardiogram of a cow with hepatocardial syndrome in the third lead

With hepatocardial syndrome in high-yielding dairy cows, the duration of absolute atrioventricular conduction does not change ($p < 0.1$), but its share in the total duration of the cardiac cycle, i.e. relative atrioventricular conduction, is significantly higher than this indicator in clinically healthy animals - 25.0 ± 1.65 % (18.1-39.5; $p < 0.01$).

The duration of ventricular electrical systole (Q-T) in the case of multiple heart and liver pathology tends to decrease, but its atrioventricular conduction tends to increase, i.e., impaired myocardial impulse conduction, compared with clinically healthy animals (39.5±2.17 %), and averaged 41.7±3.26 % (22.7-47.2).

Thus, the electrocardiogram of cows with hepatocardial syndrome is characterised by a decrease in the duration of the cardiac cycle (R-R) by 16.3 % due to a shorter myocardial rest time (diastole T-P).

The obtained results indicate that in the syndrome of heart and liver damage in the myocardium, the function of cardiac conduction is significantly impaired, rest (diastole) decreases and the duration of electrical systole increases. These results of the study of the functional state of the heart by ECG confirm the conclusion of V.P. Shishkov, who, on the basis of pathological studies, established dystrophic changes in cardiomyocytes [226].

One of the main functions of the liver is protein synthesis. Indicators of the content of total protein and its fractions in the blood serum indicate the condition of hepatocytes [128].

In 26 newly deformed cows with hepatocardial syndrome, the content of total protein in the blood serum ranged from 75.9-110.5 g/l with an average value of

89.0±1.67 g/l, which is significantly higher ($p<0.001$) than in clinically healthy animals. Hyperproteinemia (87.3-110.5 g/l) was diagnosed in 58.3 % of diseased cows.

The concentration of total protein in the blood of early lactation cows averaged 88.0±1.51 g/l (69.6-104.4), which is significantly higher ($p<0.001$) compared to clinically healthy animals. Hyperproteinemia (89.2-104.4 g/l) was observed in 41.7 % of diseased cows, and a decrease in total protein (69.6 g/l) was detected in only one (8.3 %). About half of blood proteins are albumin [209]. They regulate not only water but also mineral metabolism, as part of the calcium is bound to albumin. By forming complex compounds with bilirubin and hormones, albumin is indirectly involved in pigment, hormonal and some other types of metabolism, regulating the content of free, non-protein-bound fractions of biologically active substances with even higher biological activity [127].

The serum albumin content of newly degenerated cows with hepatocardial syndrome averaged 25.0±0.96 g/l with fluctuations of 14.9-34.0 g/l, which is significantly lower ($p<0.01$) than in clinically healthy animals (Table 8.3). In one animal (3.8 %), the albumin content was within normal limits and was 34.0 g/l.

In the blood serum of sick cows of early lactation, the concentration of albumin ranged from 13.9 to 31.9 and the average value was 23.9±0.71 g/l (Table 8.3).

Against the background of hypoalbuminemia, the number of globulin fractions increases in the blood serum of highly productive cows. The alpha-globulin fraction is formed by glycoproteins, which are referred to as proteins (‘reactants’) of the acute phase [128]. They are divided into alpha-1 and alpha-2 fractions. Alpha-1-globulins include alpha-1-lipoprotein, alpha-1-antitrypsin, alpha-1-antichymotrypsin [208]. The amount of these proteins in the blood serum of high-yielding newly calved cows is 4.7±0.57 g/l (0.9-12.1) and has no changes compared to clinically healthy animals (Table 8.3) and in the group of early lactation cows 5.7±0.41 g/l (1.0-11.4) (Table 8.4).

Table 8.3

Protein content and protein fractions in blood serum of highly productive newly bred cows, g/l

Indexes		Biochemical indexes	Clinically healthy cows (n=12)	Cows of hepatocardial syndrome (n=26)	p <
Total protein		Lim M±m	68,8–86,6 77,5±1,54	75,9–110,5 89,0±1,67	0,001
Protein fractions, g/l	Albumin	Lim M±m	23,5–37,3 29,1±1,28	14,9–34,0 25,0±0,96	0,01
	α_1 - globulins	Lim M±m	2,4–6,8 4,5±0,41	0,9–12,1 4,7±0,57	0,1
	α_2- globulins	Lim M±m	3,4–15,1 7,1±1,08	1,4–18,0 6,6±0,84	0,1
	β - глобуліни	Lim M±m	7,0–19,1 12,2±1,12	5,4–40,8 20,5±1,79	0,001
	γ- глобуліни	Lim M±m	16,7–32,2 24,6±1,43	17,3–57,2 32,2±2,01	0,001

Note. p < – compared to clinically healthy animals

Table 8.4

Indicators of protein metabolism in blood serum of highly productive cows of early lactation

Indexes		Biochemical indexes	Clinically healthy cows (n=12)	Cows of hepatocardial syndrome (n=26)	p <
Total protein		Lim M±m	71,5–88,6 80,0±1,1	69,6–104,4 88,0±1,51	0,001
Protein fractions, g/l	Albumin	Lim M±m	23,7–37,0 29,7±0,79	13,9–31,9 23,9±0,71	0,001
	α1 - globulins	Lim M±m	2,9–11,8 5,8±0,53	1,0–12,7 5,7±0,41	0,1
	α2- globulins	Lim M±m	1,9–17,5 5,6±0,92	1,0–12,4 5,7±0,45	0,1
	β - глобуліни	Lim M±m	3,9–19,6 12,2±0,93	2,7–35,0 14,5±1,27	0,1
	γ- глобуліни	Lim M±m	18,1–34,5 26,7±0,97	20,9–62,7 38,2±1,64	0,001

Note. p< – compared to clinically healthy animals

The concentration of alpha-2-globulins, which include haptoglobulin, ceruloplasmin, alpha-2-macroglobulin, alpha-lipoprotein [128], in the blood serum of highly productive newly expanded cows with hepatocardial syndrome was 6.6±0.84 g/l (1.4-18.0), and in early lactation – 5.7±0.45 g/l (1.0-12.4) (Table 8.3; 8.4) and has no changes compared to clinically healthy animals.

Thus, the total amount of alpha-globulins in the blood serum of sick newly degenerated high-yielding cows was 11.3±0.89 g/l (4.8-22.4), in animals of early lactation – 11.3±0.63 g/l (4.4-20.6). A decrease in the content of alpha-globulins in hepatocardial syndrome was observed in 38.5 % of newly deformed animals and 27.8 % of early lactation animals, and an increase – in 15.4 and 5.6 % of diseased cows, respectively.

Based on the above results, it can be argued that hepatocardial syndrome has a chronic course, since there is no reaction from the reactive protein fractions - alpha1 and alpha2 globulins.

The beta-globulin fraction is often divided into two subfractions: beta-1 and beta-2. The beta-1 fraction is formed mainly by lipoproteins. It contains about 3/4 of all plasma lipids and only 5% of protein [128].

The blood serum of sick high-yielding newly degenerated cows contains 20.5±1.79 g/l (5.4-40.8) beta-globulins, which is significantly higher than in clinically healthy animals ($p<0.001$; see Table 8.3). An increase in the concentration of this fraction of proteins against the norm was found in 84.6 % of cows, a decrease - only in one animal (3.8 %). In the blood of cows in early lactation, the content of beta-globulins tended to increase and amounted to 14.5±1.27 g/l (2.7-35.0) (see Table 8.4). Hyperbetaglobulinaemia was detected in the blood serum of 50.0 % of the diseased animals, while hypo- - in 13.9%. Such changes in the amount of β-globulins are characteristic of the chronic course of liver damage [18, 208, 209]. A decrease in their number is accompanied by an increase in gamma globulins, which indicates chronic hepatocyte damage.

Biochemical studies of blood serum of high-yielding newly degenerated cows with hepatocardial syndrome revealed that the concentration of gamma-globulin

fractions averaged 32.2±2.01 g/l with a range from 17.3 to 57.2 g/l, which is significantly ($p < 0.001$) higher than in clinically healthy animals (see Table 8.3). An increase in the number of gamma globulins was observed in the blood serum of 42.3% of cows.

The blood of sick cows in early lactation contains 38.2±1.64 g/l (20.9-62.7) of gamma globulins, which is significantly higher ($p < 0.001$) than in clinically healthy animals (see Table 8.4). An increase in the concentration of this fraction against the norm was found in 83.3 %, and a decrease in 2.7 % of the diseased animals. These changes are characteristic of chronic liver damage.

One of the indicators indicating serum dysproteinemia is the ratio of the albumin to globulin fraction (A/G, albumin-globulin ratio) [128]. In high-yielding newly bred cows with hepatocardial syndrome, the albumin-globulin ratio is 0.22-0.62, with an average value of 0.33±0.02, which is significantly lower than the normative values (0.7-1.0).

In the structure of blood serum proteins of early lactation cows with the development of hepatocardial syndrome, the ratio of albumin to globulin fractions ranges from 0.16 to 0.59, which is a typical sign of liver pathology.

In clinical diagnostic laboratories, methods are used to detect changes in the protein spectrum of serum using simple colloidal reactions. Impaired colloidal stability of serum under the influence of chemicals is manifested first by coagulation (gluing) and then by flocculation (precipitation). It is known that the resistance of the serum colloidal system to flocculation agents depends on the ratio between the content of albumin molecules (hydrophilic, protective colloids) and globulins, among which there is a large number of relatively hydrophobic proteins [128].

A positive formol colloidal precipitation reaction (from ++ to ++++) was detected in 100 % of newly calved and 97.2 % of early lactating cows with hepatocardial syndrome. Violation of the colloidal stability of serum proteins of varying degrees by reaction with 0.1 % sulemic solution was found in all newly deformed animals and early lactation cows with heart and liver damage, and 0.6-1.45 and 0.95-1.5 ml of sulemic solution were used for titration, respectively, which is

significantly less ($p < 0.001$) compared to clinically healthy cows (see Table 8.5).

Table 8.5

Results of colloidal sedimentation reactions of highly productive dairy cows

Group of cows / Indexes	Newly bred cows		Cows of early lactation	
	Clinically healthy	hepatocardial syndrome	Clinically healthy	hepatocardial syndrome
Phormole probe, +–	+ - 5 – - 7	++ -9 +++ - 8 ++++ - 9	+ - 10 – - 11	+ - 1 ++ - 15 +++ - 8 ++++ - 12
, ml	1,63±0,04	1,22±0,04*	1,61±0,03	1,27±0,02*

Note. * – $p < 0,001$ – compared to clinically healthy animals

The obtained results indicate a significant damage to hepatocytes in high-yielding cows with hepatocardial syndrome.

Positive results of colloidal sediment samples are most often due to characteristic changes in the content of certain fractions (alpha-, beta-, and gamma-globulins) and a decrease in the albumin-globulin ratio [128].

A study of the protein synthesis function of the liver in cows with hepatocardial syndrome showed that the main signs of this pathology are the development of hyperproteinemia, dysproteinemia as a result of a decrease in the amount of albumin and an increase in beta- and gamma-globulins, which is confirmed by the results of studies of formol and sulphur colloidal precipitation reactions. That is, this process is chronic.

Hyperproteinemia, dysproteinemia and hypoalbuminemia with increased beta- and gamma-globulins are typical tests of hepatodystrophy in the diagnosis of multiple heart and liver diseases in high-yield cows.

In addition to clinical examination, tonometry, and ECG recording, the determination of creatine kinase (CK), lactate dehydrogenase (LDH) and their isoenzymes, aspartate aminotransferase (AST) activity [109, 123], and blood levels of myoglobin, myosin, and cardiac troponins T and I are widely used in humane medicine to diagnose myocardial diseases [113].

A study of the serum of newly degenerated animals with signs of hepatocardial syndrome found that the average value of total creatine kinase activity was 1.8 times higher compared to clinically healthy cows ($p < 0.001$). At the same time, CK-NAC hyperfermentation was detected in 75 % of diseased animals.

The activity of total CK in the blood serum of sick cows in early lactation was 59.5±5.59 U/l (26.1-110.1) and tended to increase compared to clinically healthy cows. An increase in enzyme activity was detected in 27.8 % of animals of this technological group with hepatocardial syndrome.

The activity of total creatine kinase depends on the association of isoenzymes, namely muscle (CK-MM), cardiac (CK-MB) and brain (CK-BB) [113, 128].

The activity of the cardiac fraction of creatine kinase in the blood of high-yielding dairy cows with hepatocardial syndrome, compared with that of clinically healthy animals, significantly increases and reaches 31.6±2.02 U/l (19.3-41.3; $p < 0.001$) among newly bred animals; in early lactation cows – 31.9±3.78 U/l (13.8-88.0; $p < 0.001$). Hyperfermentation of CC-MB was observed, respectively, in 100.0 and 90.5 % of the diseased animals.

In the group of sick newly carcinogenic cows, the ratio of CK-MB activity to total creatine kinase activity was 40.5±3.96 % (26.5-69.3), which was significantly higher ($p < 0.001$) than in clinically healthy animals. In 75.0% of animals, this ratio was higher than normal.

The activity of CK-MB in early lactation cows with hepatocardial syndrome in the total activity of creatine kinase was 53.6 ± 2.96 % with fluctuations in the range of 37.2-87.6 %. An increased proportion of CK-MB in the total creatine kinase activity was detected in 100% of animals with heart and liver damage syndrome.

These data indicate the high informativeness of the cardiac isoenzyme of creatine kinase for the diagnosis of associated heart and liver disease in high-yield cows [237], especially when compared with total activity.

Lactate dehydrogenase (LDH) is a glycolytic enzyme that is widely distributed in organs and tissues that can be ranked in descending order of catalytic activity as follows: kidney, heart, skeletal muscle, pancreas, spleen, liver, lung, and serum.

Several different isoenzymes with LDH catalytic properties have been found in the latter [128].

In the blood serum of newly degenerated cows with hepatocardial syndrome, the activity of total lactate dehydrogenase averaged 381.5±13.44 U/l with a variation of 202.0 to 483.0 U/l, which is significantly higher ($p < 0.05$) than in clinically healthy animals (Fig. 8.13). Increased activity of total LDH was detected in 46.2 % of diseased cows compared to the norm.

The study of blood serum of cows in early lactation revealed a tendency to increase the total activity of LDH, compared to clinically healthy cows – 352.4±15.37 U/l (100.0-486.0) (Fig. 8.13). Hyperfermentation of total LDH was observed in 30.6 % of animals of this technological group.

It is known that the LDH1 fraction is localised mainly in the heart muscle [127]. In the blood serum of newly degenerated cows with signs of hepatocardial syndrome, the activity of the isozyme averaged 221.8±13.17 U/l with fluctuations from 79.0 to 348.0 U/l, which is significantly higher ($p < 0.01$) than in clinically healthy animals (Fig. 8.14). An increase in LDH1 activity was detected in 53.8 % of diseased animals.

In cows of early lactation with signs of hepatocardial syndrome, LDH1 activity averaged 231.6±11.58 U/l (67.0-307.0), which was significantly higher ($p<0.001$) than in clinically healthy animals (Fig. 8.14). An increase in the activity of the cardiac fraction of LDH was found in 75.0 % of the diseased animals.

An important indicator for assessing the functional state of the cardiovascular system is the proportion of cardiac isoenzyme activity in the total lactate dehydrogenase activity. During the period of severe disease development, not only the activity of LDH1 and LDH increases, but also their ratio. Thus, in hepato-cardiac syndrome in newly tumoured animals, the ratio of LDH1 activity to total LDH was 58.1 ± 2.39 % (33.6-77.8), which is significantly higher ($p < 0.01$) compared to clinically healthy cows. These changes are characteristic of increased cytolysis of cardiomyocytes, resulting in an increase in the activity of the cardiac fraction of lactate dehydrogenase, which was found in 76.9 % of the diseased animals.

Among the diseased cows of early lactation, the proportion of cardiac

isoenzyme in the total LDH activity was 65.7 ± 1.65 % with fluctuations from 67.1 to 81.9 % and was significantly higher ($p < 0.001$) than in clinically healthy animals. An increase in the ratio of LDH1/ LDHtotal was observed in 83.3 % of cows of this technological group.

In the case of hepatocardial syndrome, the heart muscle of highly productive dairy cows undergoes changes characteristic of CID, so an increase in LDH and LDH1 activity is informative for the diagnosis of this pathology. In addition, cardiac muscle lesions are also characterised by an increase in the activity of ALT [125, 126, 238]. In the blood serum of newly degenerated animals with hepatocardial syndrome, it averaged 2.29±0.09 mmol/h×l (1.6-3.58), which is significantly higher ($p < 0.001$) than in clinically healthy cows (Fig. 8.15). An increase in enzyme activity (over 2.0 mmol/h×l) was found in 73.1 % of diseased animals.

In cows of early lactation with multiple heart and liver pathologies, the activity of AST tended to increase compared to clinically healthy animals, with an average value of 2.05±0.06 mmol/h × l with fluctuations in the range of 1.26-2.94. Hyperfermentation was observed in 58.3 % of cows.

In newly degenerated cows with hepatocardial syndrome, AlAT activity averaged 0.82±0.05 mmol/h × l (0.35-1.42), which is higher than in clinically healthy animals (Fig. 8.16). Hyperfermentation was detected in only 19.2% of cows. At the same time, in the group of sick cows of early lactation, ALAT activity had only a tendency to increase compared to clinically healthy cows, and the average value of the enzyme was at the level of 0.9±0.05 with a fluctuation of 0.27-1.32 mmol/h × l. An increase in enzyme activity was noted in 44.4 % of animals of this technological group.

In the group of newly degenerated cows with heart and liver damage, the activity of AsAT increased by 19.9 and AlAT by 5.1 % compared to clinically healthy animals, in dairy cows, respectively, by 4.8 and 10.8 %.

Hyperenzymemia of LDH, CK and their cardiac-specific isoenzymes indicates their informative value in the case of combined heart and liver damage. The relative proportion of LDH1/LDH and CK-MB/CK-NAC in diseased animals increases,

which is typical for both ICD and hepatocardial syndrome. Hepato-cardiac syndrome in dairy cows is manifested by an increase in the activity of asparagine and alanine transferases.

In hepatocardial syndrome, dystrophic changes develop in the organs, which are confirmed by the results of their clinical examination and laboratory analysis of the blood of diseased cows.

The causes of this syndrome include ketosis, endometritis, mastitis, and limb damage in high-yield cows, as well as a deficiency of easily fermentable carbohydrates, digestible protein, calcium, phosphorus, zinc, cobalt and iodine in the diet of dairy cows. An imbalance in the ratio between easily fermentable carbohydrates and protein causes changes in rumen pH, which are characterised by increased synthesis of biologically active and toxic substances. The increased concentration of the latter causes hepatocyte dystrophy. On the other hand, the lack of fibre in the diet of dry cows at Terezino, dairy cows at Terezino and Glushki Agrofirm LLC in the summer causes the accumulation of toxins in the animals' bodies. The detoxifying function of the liver decreases, and toxic substances accumulate in hepatocytes and cause hepatodystrophy [18].

Toxic substances enter the coronary circulation with the bloodstream and then the myocardial cells. Intracellular metabolism is disrupted in cardiomyocytes. At the same time, intracellular enzymes (LDH, CK) and components of cardiomyofibrils (cardiotroponins) are released into the intercellular space and then into the blood. Violation of biochemical balance in myocardial cells causes dysfunction in the heart, characterised by changes in electrical potentials in the myocardium, a decrease in the tone of the heart muscle and arterial blood pressure. Stagnation of venous blood in the portal vein of the liver, due to a decrease in systolic blood pressure [236], causes secondary dystrophic changes in hepatocytes.

9. TREATMENT OF COWS WITH MYOCARDIAL DYSTROPHY AND WITH HEPATOCARDIAL SYNDROME

Myocardial dystrophy often occurs as a secondary disease as a complication of other diseases accompanied by metabolic disorders (protein, carbohydrate-lipid, mineral and vitamin), acute or chronic intoxication.

In highly productive cows, the pathology often develops as a result of an unbalanced diet in terms of essential nutrients. In some farms, cardiovascular disease is diagnosed in 10-35 % of high-yield cows [207].

Given the high prevalence of myocardial dystrophy among high-yield cows (Section 5), we conducted experimental studies on the treatment of diseased animals. For this purpose, we selected two experimental groups of cows with MCD (10 heads) and hepatocardial syndrome (10 heads). The control group consisted of 5 clinically healthy animals. Cows were examined before treatment, on days 7, 14, 30 and 60 of the experiment.

In 5 clinically healthy cows, there were no edema in the underarm area and distal limbs. The heartbeat was localised, of moderate strength, not painful, rhythmic, and the pulse rate at the beginning of the experiment was 71±2.15 beats/min (66-76). During percussion of the heart area, a muffled sound was heard, the borders of the heart were not changed. Auscultation of the heart revealed that the tones were rhythmic, clear, clear in tone, without extraneous noise.

In 10 cows with myocardial dystrophy, at the beginning of the experiment, the heartbeat was localised, weakened, not painful, rhythmic, the heart rate was 84±0.65 beats/min (80-88) and was significantly higher than in clinically healthy animals ($p < 0.001$). Tachycardia (82-88 beats/min) was noted in 90% of cows in this group. During auscultation of the heart, an increase in one or two tones was detected in 30.0% of animals, a weakening of tones – in 50.0 %, and bifurcation – in 20.0 % of the total number of cows with myocardial dystrophy.

In sick cows with hepatocardial syndrome (n=10), the heartbeat at the beginning of the experiment was localised, weakened, not painful, rhythmic, the heart

rate was 85±2.16 beats/min (78-98) and was significantly higher than in clinically healthy animals ($p < 0.001$). Tachycardia (84-98 beats/min) was noted in 60 % of cows in this group. Auscultation of the chest in the heart area revealed the following changes in tones: increase – in 20.0 % of animals, decrease – in 70.0 % and bifurcation of tones – in 10.0 % of the total number of animals studied in this group.

For the treatment of high-yielding cows with myocardial dystrophy and hepatocardial syndrome, we have developed and experimentally substantiated a comprehensive scheme based on the expediency of using medicines and providing for a) rapid action on myocardial metabolism, lack of cumulative properties and low toxicity, desirable side diuretic effect (strophanthin-K); b) intensification of metabolic processes in the liver, which is manifested by detoxifying effect with subsequent excretion of metabolites through the kidneys along with toxic products (20 % glucose solution, insulin); c) effect on intracellular metabolism of cardiomyocytes and hepatocytes along with antioxidant effect (drugs catozal and introvit) (Table 9.1).

On the 7th day of treatment, the heart rate in cows with myocardial dystrophy significantly decreased to 80.0±1.3 beats/min (74-86) compared to the beginning of the experiment ($p < 0.001$). Along with tachycardia (in 50 % of animals), auscultation of the heart revealed changes in tones: amplification and attenuation in two animals, respectively, and splitting of the first tone in one animal. On the 14th day of the experiment, the heart rate was 78±1.08 beats/min (72-82), and auscultation of the heart was observed to weaken in one cow and strengthen in the other. Starting from the 30th day of the experiment, no changes in heart sounds were detected during auscultation. On days 30 and 60, the heart rate was 75±1.08 (72-80) and 74±0.96 beats/min (68-78), respectively, and the difference with clinically healthy animals was not significant ($p < 0.1$; $p < 0.1$; Fig. 9.1).

On the 7th day of treatment, the heart rate in cows with myocardial and hepatodystrophy (hepatocardial syndrome) was 82±1.95 beats/min (74-92). Tachycardia was diagnosed in 50 % of cows. Tone changes were detected in 6 animals of the group, of which 66.7 % had increased tones and 33.3 % had decreased

tones. On day 14 of the study, the heart rate in these animals averaged 78±1.52 beats/min (72-86) and was significantly lower compared to the beginning of treatment ($p < 0.01$, Fig. 9.1). During auscultation of the heart, an increase in tones was noted in 66.7 % of animals of this experimental group, and in 33.3 % of cows – a decrease. On days 30 and 60 of the study, the heart rate significantly decreased compared to the beginning of the experiment and was 74±1.3 (68-80) and 72±1.41 beats/min (70-78), respectively ($p < 0.001$; Fig. 9.1). No changes in heart sounds were noted during this period.

Table 9.1

Treatment regimen for highly productive cows with myocardial dystrophy and hepatocardial syndrome

Medicine	Dosage and pharmacological action
Strophantine-K (0,025 % solution)	5 ml per animal intravenously with glucose solution 5 times in 1 day. It improves myocardial metabolism, is a cardiotonic agent and has a diuretic effect
10 % solution glucose	400 ml per animal 5 times a day. Energy, antitoxic and diuretic agent
Insuline solution (100 U/ml)	0.5 ml per animal subcutaneously 30-60 minutes before administration of glucose solution 5 times in 1 day. Stimulates the conversion of glucose to glycogen
Katosal (10 % solution)	20 ml intravenously with glucose 5 times a day. Improves intracellular metabolism, increases metabolism
Introvit (olium solution)	15 ml intramuscularly 4 times a day. It has a positive effect on metabolism, antioxidant and haemopoietic effects

The blood pressure values in clinically healthy animals at the beginning of the experiment were: systolic blood pressure (SBP) – 118.0±4.29 (110.0-130.0); diastolic blood pressure (DBP) –1 46.0±2.15 (40.0-50.0) and pulse blood pressure (PBP) – 72.0±4.29 mm Hg (60.0-80.0). Throughout the experiment, fluctuations in this group were insignificant (Table 9.2).

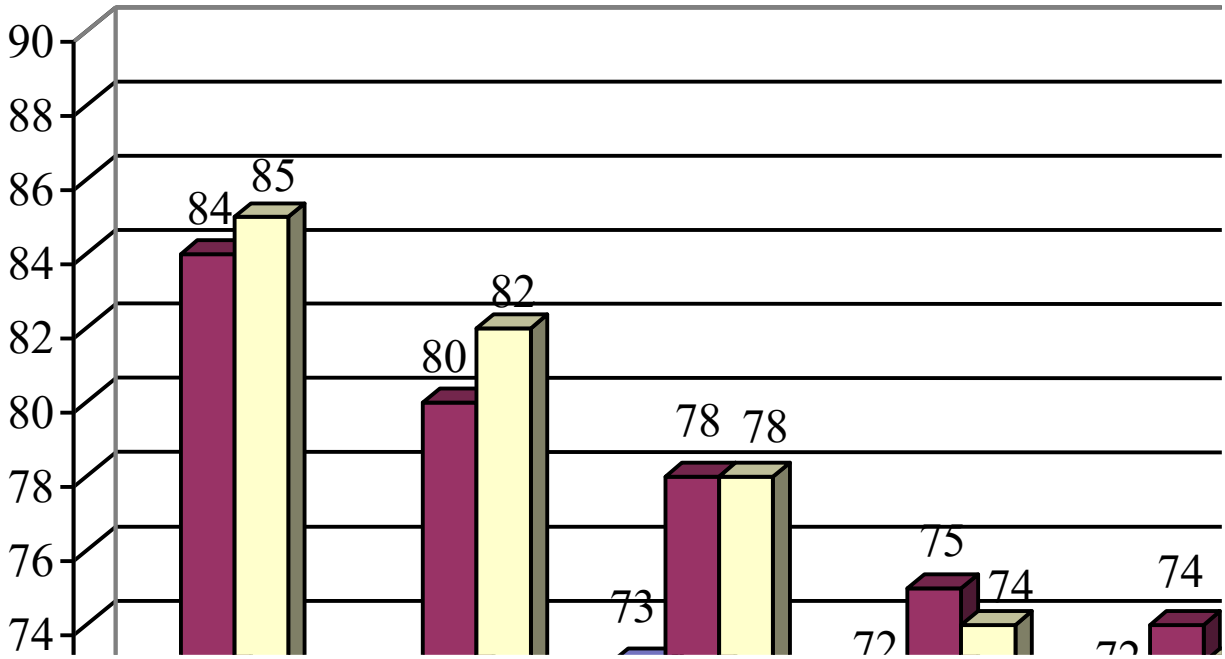

Figure 9.1. Dynamics of heart rate in high-yield cows, bpm

In cows with myocardial dystrophy (experimental group 1), at the beginning of the study, a significant decrease in systolic ($p < 0.001$), diastolic ($p < 0.01$) and pulse ($p < 0.05$) blood pressure was observed compared to clinically healthy animals. The difference between them was 15.3 %, 17.4 and 13.9 %, respectively. In 80 % of cows in this group, SBP was below physiological values. Starting from the 14th day of the experiment, SBP significantly increased ($p < 0.001$) compared to the baseline values of this group, and DBP and PAP tended to increase.

In animals with multiple pathology (2nd experimental group), a tendency to decrease blood pressure values was noted before treatment compared to clinically healthy animals. Thus, the difference between SBP was 8.5 %, DBP – 13.0 and PAP – 5.6 %. In 60% of cows in this group, systolic pressure was less than the lower physiological limit. Starting from day 7, cows with hepatocardial syndrome showed a tendency to increase, and on days 30 and 60 of the experiment – a significant increase in diastolic blood pressure compared to the indicators of this group at the beginning of the experiment ($p < 0.05$; $p < 0.01$; see Table 9.2), which is explained by the positive effect of cardiac glycosides on the myocardium and improved energy supply of the heart muscle.

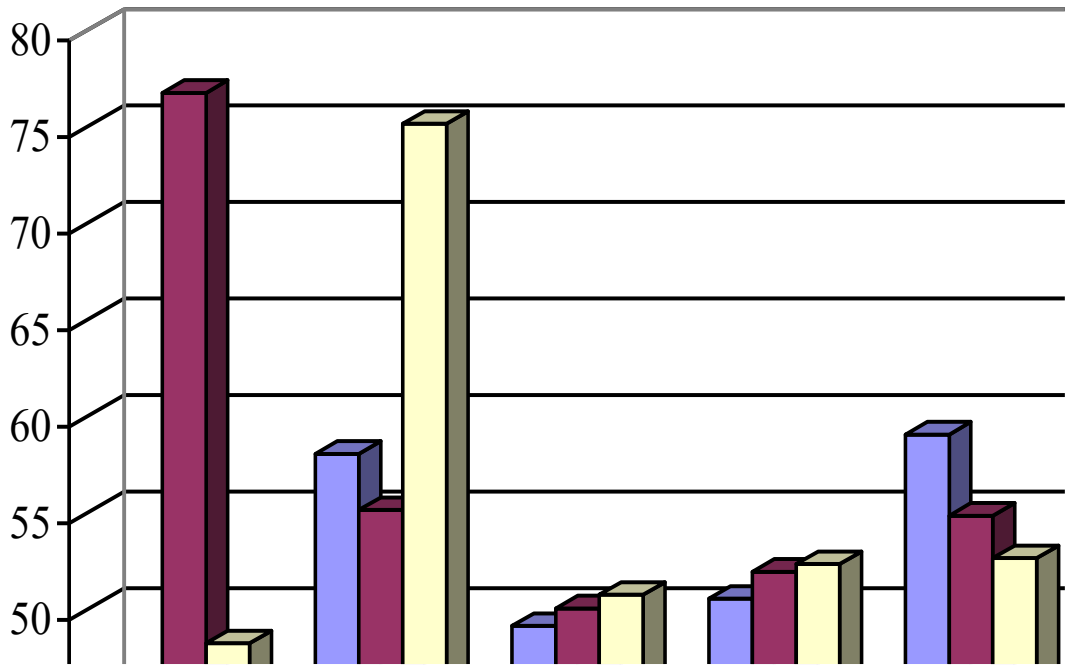

Figure 9.2. Dynamics of CK-NAC activity in high-yielding cows, U/l

Thus, the use of cardiac glycosides has a positive effect on the functional state of the heart and improves metabolism in cardiomyocytes.

The effectiveness of treatment of sick animals was also monitored by the results of the study of cardiac-specific enzymes CK and LDH.

In the group of clinically healthy cows, the activity of total CK and its myocardial isoenzyme was 43.4±3.84 (37.1-55.0) and 13.0±2.62 U/l (5.8-18.0), respectively. During the whole experiment, the fluctuation of indicators was insignificant.

In the serum of animals with myocardial dystrophy, a significant increase ($p < 0.05$) in the activity of total creatine kinase (CK-NAC) was found in relation to the parameters of clinically healthy animals. The activity of the cardiac isoenzyme in this group at the beginning of the study was 34.7±4.17 U/l (19.3-57.8) and was 2.7 times higher than in control animals. An increase in the activity of total creatine kinase was observed in 50 % of cows, CK-MB - in 90 %. Intravenous administration of therapeutic doses of strophanthin normalised the activity of creatine kinase, especially its cardiac fraction CK-MB. Starting from day 7 of the study in animals with myocardial dystrophy, the activity of KK-NAC tended to decrease, and CK-MB

significantly decreased ($p < 0.001$) compared with the initial values. At the same time, the activity of CK-NAC and myocardial isoenzyme remained elevated in 10% of animals one week after the start of treatment. On the 60th day of the experiment, the activity of CK-NAC and CK-MB in animals with MCD tended to decrease compared with that in clinically healthy cows. The activity of total CK and its isoenzyme CK-MB decreased by 40.0 and 180 % compared with the initial data. Increased activity of the cardiac isoenzyme CK was observed in 10 % of animals in this group (Fig. 9.2; 9.3).

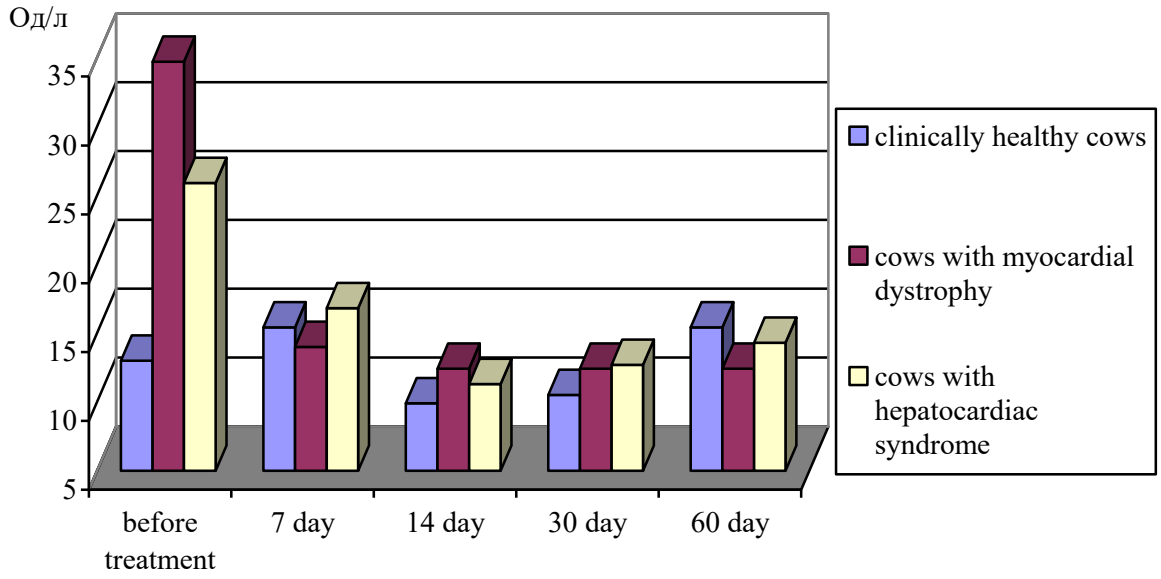

Figure 9.3. Dynamics of CC-MB activity in high-yielding cows

In the group of cows with hepatocardial syndrome, at the beginning of the study, there was a tendency to increase the activity of total creatine kinase and its cardiac isoenzyme, which was 48.3±9.09 (26.1-110.1) and 25.9±4.17 U/L (13.8-52.3) and was significantly higher ($p < 0.001$) compared to clinically healthy animals. An increase in the activity of the cardiac fraction of CK (more than 20 U/l) was diagnosed in 60 % of the diseased animals. On day 7 of the experiment, a significant increase in CK-NAC activity was observed in cows with heart and liver damage compared to the initial values. In 30 % of animals in this group, the activity of total creatine kinase was higher than normal, which may be due to an increase in the activity of muscle and nerve isozymes, the activity of myocardial isozyme was

increased in 40 % of cows (initially 60 %). Starting from the 14th day of the study, the activity of CK-MB in cows of this group significantly decreased ($p < 0.01$) compared to the initial values. On the 60th day of the experiment, an increase in the activity of the myocardial CK isoenzyme was detected in only 10 % of cows in this group (Fig. 9.2; 9.3).

At the beginning of the study, a significantly higher ratio of CK-MB/CK-NAC was observed in the groups of animals with myocardial dystrophy ($p < 0.05$) and heart and liver dystrophy ($p < 0.001$) compared to clinically healthy animals, which was 45.2 ± 5.14 (22.5-70.0) and 53.6 ± 3.43 % (37.2-78.5), respectively, against 30.0 ± 4.7 % (15.6-37.5) in clinically healthy cows. This index was higher than normal in 60% of animals with myocardial dystrophy and 90% of animals with multiple pathologies. On day 60 of the experiment, the ratio of CK-MB activity to total creatine kinase activity in cows with myocardial dystrophy was 22.6 % lower, and in cows with hepatocardial syndrome – 26.5 %, compared to the beginning of the experiment. During this period, in the group of animals with myocardial dystrophy, there was a tendency to decrease CK-MB/CK-NAC at average values of 22.6±2.78 % (5.7-38.1) against 26.1±5.98 % (12.5-32.4) in clinically healthy animals (Fig. 9.4).

At the beginning of the study, in animals with myocardial dystrophy and hepatocardial syndrome, the activity of lactate dehydrogenase and its cardiac-specific isoenzyme LDH1 was, respectively, 415, 6±15.15 (354.0-494.0) and 259.4±9.52 U/l (220.0-308.0) and 408.2±10.61 (375.0-473.0) and 274.1±7.9 U/l (234.0-307.0), were significantly ($p < 0, 001$) higher compared to healthy animals 321.2 ± 7.73 (338.0-302.0) and 139.2 ± 9.66 U/l (114.0-159.0).

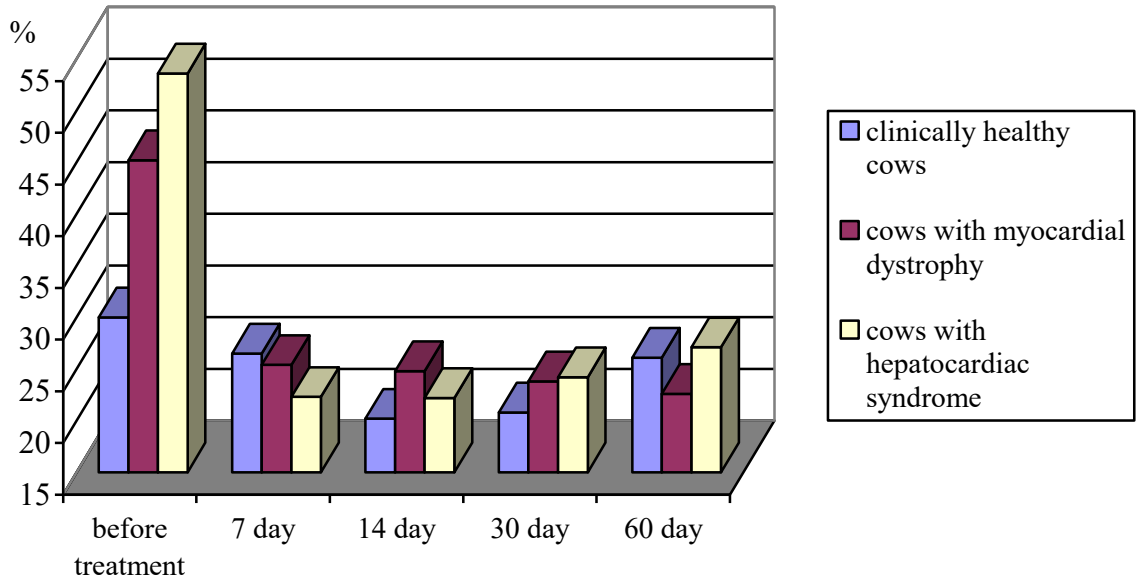

Figure 9.4. Dynamics of CK-MB/CK-NAC in high-yielding cows

In one animal with mixed pathology of the heart and liver, the activity of total LDH was higher than normal. The activity of myocardial isoenzyme in all animals of both experimental groups was higher than the maximum physiological limit. After the complex treatment, starting from day 7 of the experiment, a significant decrease ($p<0.001$) in the activity of LDH and LDH1 was observed in both experimental groups (Figs. 9.5; 9.6).

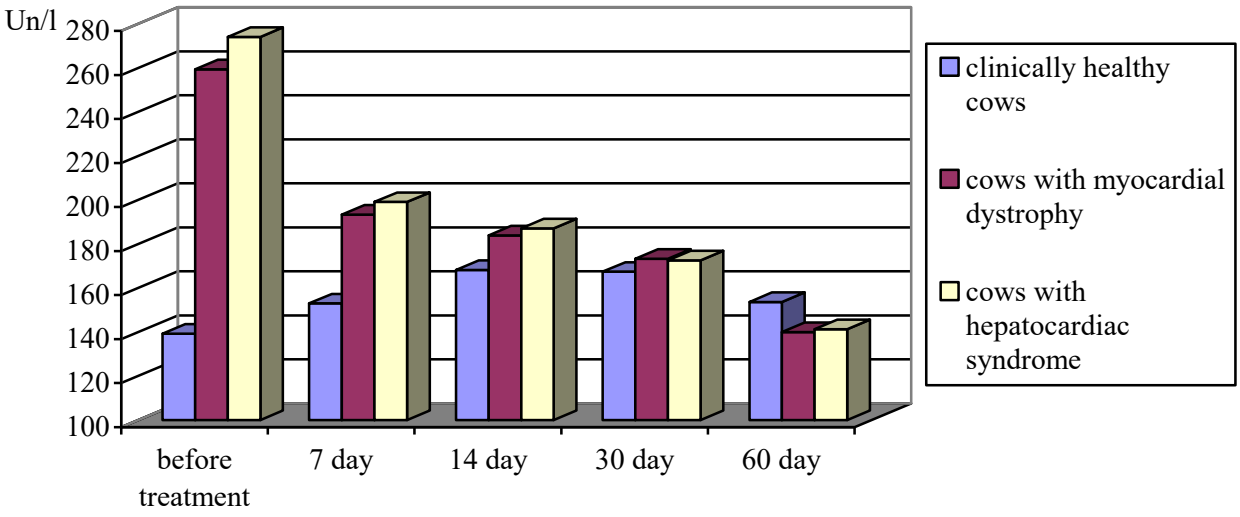

Figure 9.5. Dynamics of LDH activity in high-yielding cows

From day 14 of the study, no significant difference was observed between the values of clinically healthy and diseased animals. On day 60 of the experiment, the activity of these biochemical markers in the groups of animals with myocardial dystrophy and hepatocardial syndrome tended to decrease compared to clinically healthy animals. In the animals of the first and second experimental groups, the activity of total LDH was 357.4±10.12 (296.0-399.0) and 327.6±17.36 (238.0-381.0), respectively, against 364.6±4.63 U/l (351.0-378.0) in the control group. LDH1 activity in both study groups was within normal limits. Compared with the pre-treatment values, on day 60 of the study, the activity of total lactate dehydrogenase decreased in the group of animals with MCD by 16.3%, and in cows with hepatocardial syndrome - by 24.6%, and LDH1 - by 85.3% and 94.0%, respectively (Fig. 9.6).

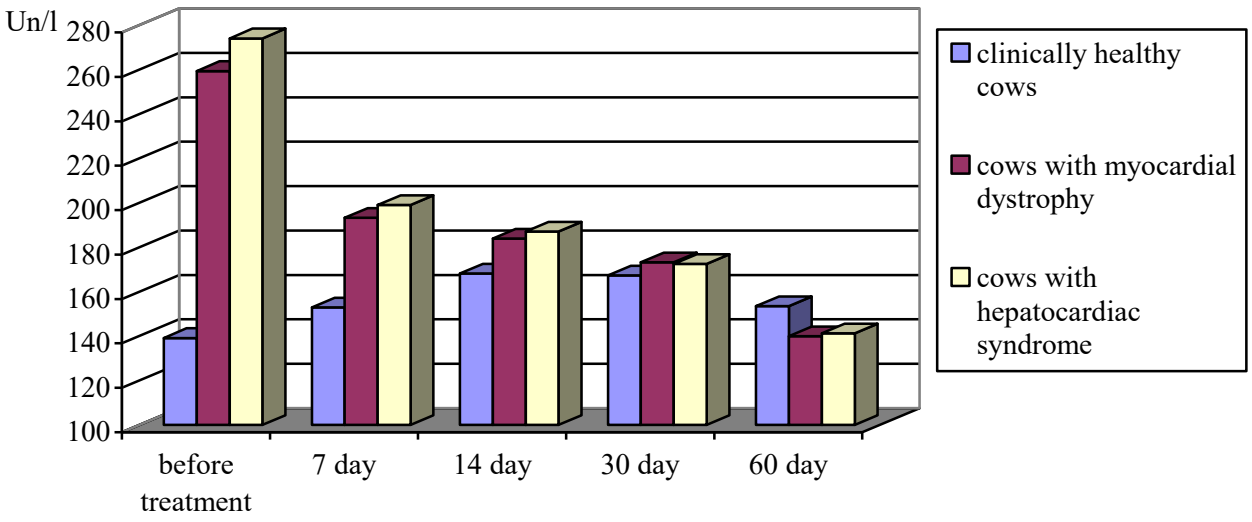

Fig. 9.6. Dynamics of LDH1 activity in high-yielding cows

At the beginning of the experiment, the ratio of LDH1/LDH in the groups of cows with myocardial dystrophy and hepatocardial syndrome was significantly higher ($p<0.001$) than in clinically healthy animals and was 62.4±3.4 (52.3-83.7) and 67.2±2.98 (51.2-78.7), respectively, against 43.3±2.73 % (36.1-48.8) (Fig. 9.7).

Starting from day 7 of the study, the proportion of myocardial isoenzyme in the total LDH activity in the groups of animals with heart damage and multiple pathology was 50.9±1.37 and 52.0±1.75 against 44.1±2.79 % in clinically healthy animals and

significantly decreased ($p < 0.001$; $p < 0.01$) compared to the initial values. In 70 % of cows with myocardial dystrophy and 90 % of animals with hepatocardial syndrome, the LDH1/LDH ratio was within physiological values. On day 60 of the experiment, the proportion of LDH1 in the total lactate dehydrogenase activity in cows of the first experimental group was 39.2±1.45 % (32.5-43.9), and in the second – 43.1±1.42 (34.2-49.0) against 42.1±1.93 % in the control group. In all cows with myocardial dystrophy and multiple pathology, the ratio of LDH1/LDH after treatment was within normal limits (Fig. 9.7).

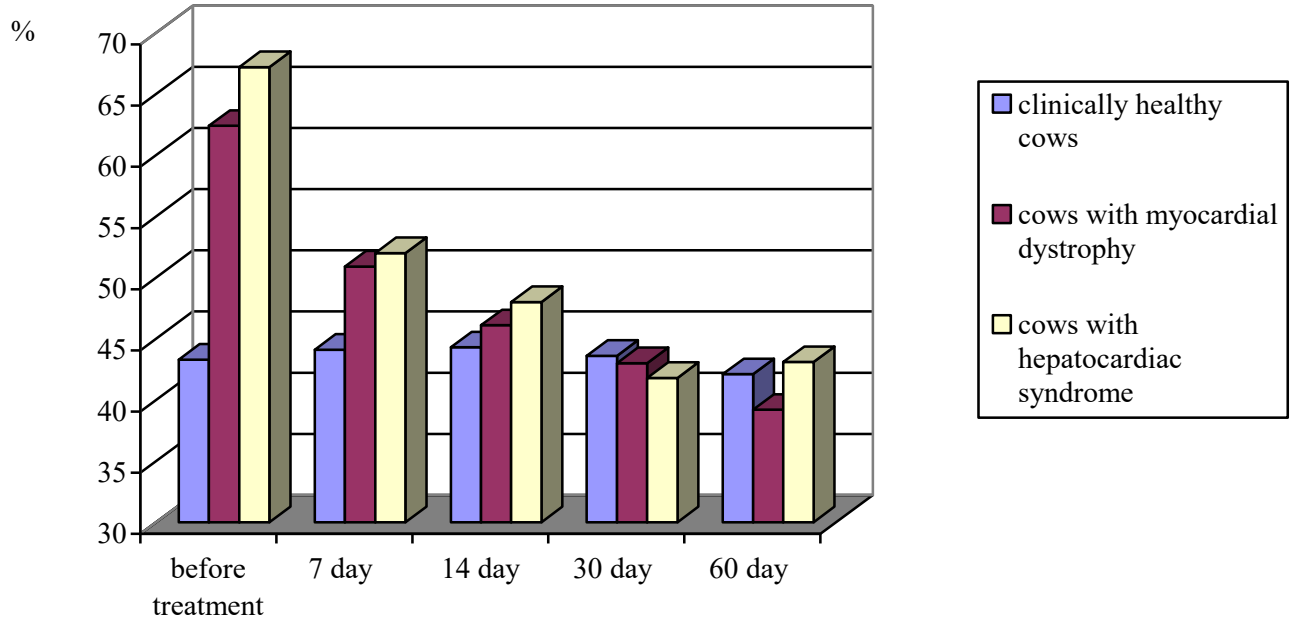

Figure 9.7. Dynamics of LDH1/LDH_{total} in high-yield cows

The effectiveness of the treatment was also monitored by the results of the study of the protein spectrum of the blood serum of the diseased animals. We found that before treatment, the content of total protein in the blood serum of cows with myocardial dystrophy and hepatocardial syndrome was significantly higher ($p < 0.05$) than in clinically healthy animals. Among the cows of the 1st experimental group, hyperproteinemia was observed in 20 % of animals, and in the 2nd experimental group – in 50 %. On day 14 of the experiment, a significant decrease in the content of total protein in the blood serum of cows with myocardial dystrophy ($p < 0.001$) and

in animals with multiple pathologies ($p < 0.05$) was noted compared to pretreatment values (Table 9.2).

Table 9.2

Dynamics of total protein and its fractions in the blood serum of highly productive cows during the experiment

Indexes	Group of animals		Period of research			
		Before treatment	7 day	14 day	30 day	60 day
Total protein, g/l	Healthy animals	78,7±1,7	82,6±1,06	79,2±2,17	79,4±1,03	82,7±0,97
	1st group	84,0±1,28*	85,6±2,2	76,0±1,36***	84,0±2,05	80,1±1,6
	2nd group	85,3±2,05*	87,6±1,59*	78,9±2,24*	84,2±1,93*	78,3±1,74* **
Albumen, %	Healthy animals	38,8±0,9	39,1±1,78	38,5±1,65	39,4±1,22	41,3±1,35
	1st group	41,6±0,57**	35,0±1,57***	34,2±0,9***	34,9±1,17***	40,9±1,0
	2nd group	24,4±1,35***	32,4±0,77***	31,7±0,98***	33,0±1,17***	37,3±1,41***
α_1 globulins, %	Healthy animals	6,4±0,39	8,5±2,02	6,0±0,73	6,6±0,34	5,9±0,42
	1st group	6,6±0,3	6,9±0,49	7,1±0,57	7,3±0,62	6,5±0,28
	2nd group	7,8±3,29	6,8±0,5	7,1±0,28	7,2±0,82	5,8±0,27
α_2 globulins, %	Healthy animals	6,4±0,73	5,8±1,27	6,7±1,22	6,7±0,54	6,1±0,53
	1st group	6,3±0,43	7,9±0,61*	6,2±0,35	6,7±0,4	6,1±0,4
	2nd group	7,2±0,82	9,1±1,13	6,5±0,45	7,5±0,51	6,3±0,42
β globulins, %	Healthy animals	15,5±1,72	16,0±0,75	16,7±0,73	17,0±0,52	16,0±0,28
	1st group	14,5±0,7	15,4±0,4	16,8±0,52**	15,8±0,34	16,2±0,29*
	2nd group	15,9±0,29	15,8±0,29	16,0±0,44	17,0±0,57	16,1±0,44
γ globulins, %	Healthy animals	32,9±0,45	31,4±2,4	32,2±1,65	30,4±1,2*	30,9±2,04
	1st group	31,0±0,9	35,1±1,68*	35,8±1,22**	35,3±0,95***	30,4±1,01
	2nd group	41,7±1,41***	35,6±1,04***	37,9±0,77***	35,4±0,8***	34,5±1,21***

Note: * – p< 0,05**;** ** – p< 0,01; *** – p< 0,001 vertically – experimental groups in comparison with control groups, horizontally – in comparison with pre-treatment values; 1st experimental group – cows with myocardial dystrophy; 2nd experimental group – cows with hepatocardial syndrome

On the 60th day of the experiment, the level of total protein in the blood serum of cows with multiple pathology averaged 78.3±1.74 (71.4-86.3) g/l and was

significantly lower ($p < 0.05$) compared to cows of the control group, and compared to the beginning of the experiment, it decreased by 8.9 %. In the group of animals with myocardial dystrophy, this test tended to decrease (Table 9.3).

Table 9.3

Dynamics of formol and sulemol test and activity of asparagine and alanine transferases in high-yielding cows

Indexes	Group of animals	Period of research				
		Before treatment	7 day	14 day	30 day	60 day
Phormole probe, –+	Control group	– - 5	– - 4 + - 1	– - 4 + - 1	– - 5	– - 5
	1st group	– - 10	++ - 4 + - 3 – - 3	++ - 3 + - 4 – - 3	++ - 3 + - 3 4	+ - 1 – - 9
	2nd group	++++ - 3 +++ - 3 ++ - 4	+++ - 1 ++ - 6 + - 2 – - 1	+++ - 2 ++ -5 +- 2 1	+++ - 2 ++ - 2 + - 5 1	+ -5 – -5
Sulema probe, мл	Control group	1,68±0,04	1,65±0,06	1,73±0,09	1,72±0,04	1,72±0,04
	1st group	1,67±0,02	1,5±0,03***	1,5±0,03***	1,53±0,03***	1,68±0,03
	2nd group	1,27±0,04***	1,44±0,04***	1,39±0,04***	1,46±0,04***	1,6±0,04***
AsAT, mmol/ h·× l	Control group	1,67±0,07	1,76±0,06	1,91±0,03**	1,92±0,04**	1,73±0,06
	1st group	1,85±0,06	1,76±0,07	2,0±0,04*	1,99±0,05	1,64±0,04**
	2nd group	1,96±0,06**	1,73±0,06**	2,0±0,03 *	1,82±0,09	1,53±0,05***
AlAT, mmol/ h·× l	Control group	0,89±0,09	0,95±0,06	0,9±0,07	0,9±0,1	0,77±0,07
	1st group	0,98±0,07	0,81±0,07	0,97±0,02	0,94±0,05	0,65±0,05***
	2nd group	0,83±0,08	0,84±0,07	0,97±0,03	1,0±0,04	0,6±0,07*

Note: * – p< 0,05**;** ** – p< 0,01; *** – p< 0,001 vertically – experimental groups in comparison with control groups, horizontally – in comparison with pre-treatment values; 1st experimental group – cows with myocardial dystrophy; 2nd experimental group – cows with hepatocardial syndrome

One of the indicators characterising the state of protein synthesis function of the liver is the albumin content. In animals with myocardial dystrophy, a decrease in albumin content was observed within 30 days, while the concentration of β- and γ-globulin fractions increased. However, on the 60th day of the study, the albumin content returned to normal. In cows with multiple pathologies, the albumin content before treatment was significantly lower ($p < 0.001$) than in clinically healthy animals. Starting from the 7th day of the experiment, a significant increase ($p < 0.001$) in the content of fine proteins was observed compared to the baseline values. At the same time, the concentration of gamma globulins in the blood serum significantly decreased ($p < 0.05$; $p < 0.001$).

The state of hepatocytes is also evidenced by the data of formic and sulphuric colloidal precipitation reactions. Thus, in the group of animals with myocardial dystrophy, from day 7 to day 30, a slightly positive formol test (++) was observed in 40 % of cows, a significant decrease ($p < 0.001$) in the sulem test (by 11.3 %) compared to the beginning of the experiment. On the 60th day, these indicators were normalised (Table 9.4).

In the group of animals with hepatocardial syndrome, starting from day 7 of the study, a significant ($p < 0.001$) increase in the sulemic test was observed. On the 60th day of the experiment, the indicators of colloidal stability of proteins were normalised, only a significant decrease ($p < 0.05$) in the sulemic test was observed in animals of the 2nd experimental group compared to the control group (Table 9.3). The results of the sulem test in cows with hepatocardial syndrome improved by 20.6 % compared to the beginning of the study.

The activity of asparagine and alanine transaminases in cows with myocardial dystrophy tended to increase. In animals with multiple pathologies (myocardial and hepatodystrophy), there was a significant increase ($p < 0.01$) in the activity of AsAT, which was 1.96±0.06 mmol/h × l. In one cow of this group, AlAt activity was increased against the norm to 1.34 mmol/h × l.

In the group of clinically healthy cows, a significant ($p < 0.001$) increase in the activity of ALT on days 14 and 30 of the study by 14.4 and 15.0%, respectively, was observed, indicating an increase in hepatocyte activity due to the introduction of therapeutic doses of glucose and oversaturation of the animal diet with protein (Table 9.3) [128].

The use of nonspecific therapy led to an increase in the activity of AsAT and AlAT on the 14th and 30th day of treatment in animals of the experimental groups. On the 60th day of the experiment, the activity of asparagine and alanine transaminases in cows with myocardial dystrophy was significantly reduced ($p<0.01$; $p<0.001$) compared to the beginning of the experiment.

In cows with myocardial and hepatodystrophy, on day 60 of the experiment, the activity of AsAT and AlAT were significantly reduced ($p < 0.001$; $p < 0.05$), respectively, by 33.7 % and 37.7 % compared to the values at the beginning of the experiment (Table 9.3).

Comprehensive treatment with the inclusion of complex preparations of cardiac glycosides of plant origin in the standard therapy leads to an improvement in the clinical condition of animals. The use of these drugs does not cause serious side effects on the heart (rhythm disturbances, cardiac conduction). Cardiac glycoside preparations in combination with glucose and vitamins affect not only the cardiovascular system, but also the nervous and urinary systems. Under their influence, a positive inotropic effect is realised, and the cardiac output per minute increases, which is characterised by an increase in myocardial contractility and cardiac pumping function.

In this case, not only the general condition of high-yielding cows improves, but also their biochemical status: the activity of LDH, CK, aspartic and alanine aminotransferases, and the protein synthesis function of the liver are normalised. Complex therapy based on the use of cardiac glycoside preparations improves not only cardiac function, but also improves the functional activity of hepatocytes together with vitamin preparations. Electrocardiographic studies conducted before treatment, 7 and 30 days after it showed that cardiac glycosides together with vitamin preparations cause positive changes in the electrical activity of the myocardium of cows with myocardial dystrophy and hepatocardial syndrome.

The analysis of the ECG of the diseased cows indicated that the cardiac cycle was rhythmic, since the maximum fluctuations in the duration of the R-R interval did not exceed 10% and were within 9.2 %. The rhythm is sinus, the alternation of the teeth is sequential.

We found that in high-yielding cows with MCD, the Q tooth is not pronounced, the R tooth is well expressed in 85.7 % of animals (Fig. 9.8).

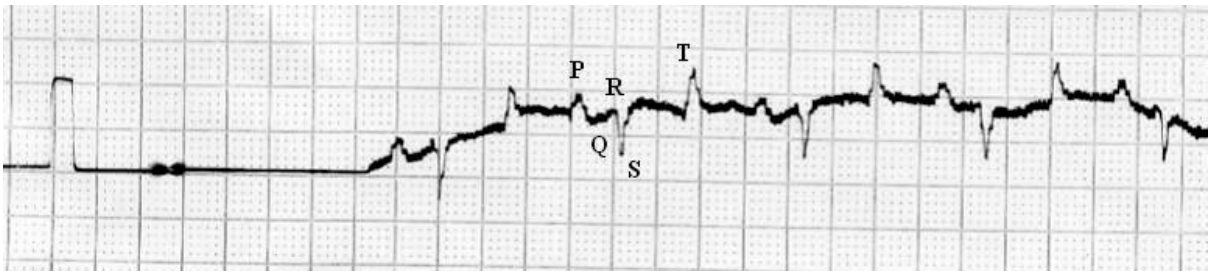

Figure 9.8**.** Electrocardiogram of a cow with myocardial dystrophy

In one sick cow (14.7 %), a negative T tooth with a voltage of –0.3 mV was detected (Fig. 9.9).

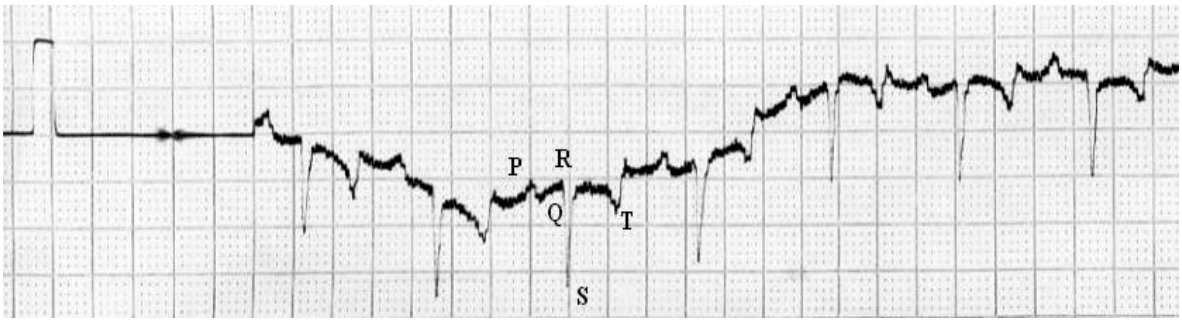

Figure 9.9. Negative T wave in the second lead on the ECG of a cow with myocardial dystrophy

In high-yielding cows of the second group, similar changes in the electrocardiogram were found to the previous one: the lack of expression of the Q wave, low voltage of the R wave (0.03-0.27 mV), expressed in 77.8 % of animals (Fig. 9.10), negative T wave in 11.1 % of animals with a voltage of 0.33 mV (Fig. 9.11).

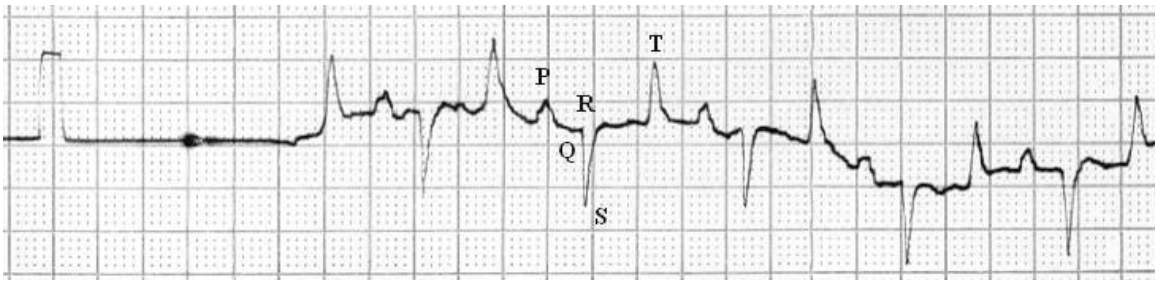

Figure 9.10. Electrocardiogram of a cow with hepatocardial syndrome

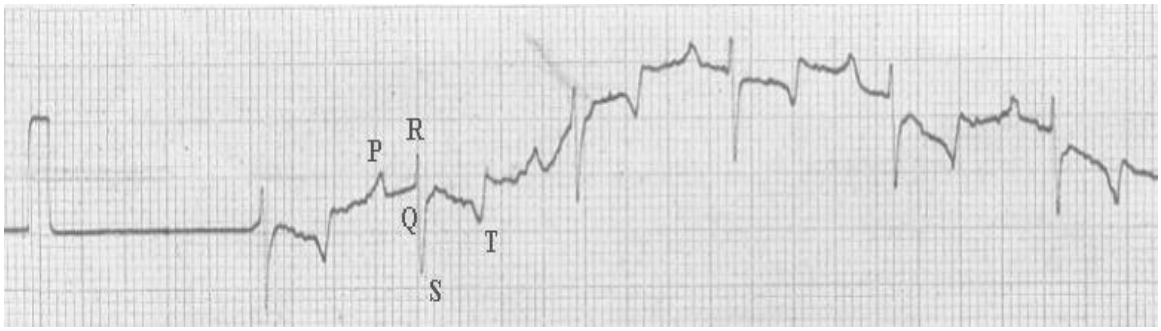

Figure 9.11. Negative T wave in the second lead on the ECG of a cow with hepatocardial syndrome

In high-yielding cows with myocardial dystrophy, the P-wave voltages tended to decrease over the entire period of study. The T-wave voltages significantly decreased on the 7th ($p < 0.01$) and 30th day ($p < 0.05$) of the study, to +0.28±0.032 mV and +0.32±0.032 mV, respectively, indicating a gradual repolarisation of cardiomyocytes at the end of systole (Table 9.9).

On days 7 and 30 of the study after therapeutic intervention in high-yielding cows with hepatocardial syndrome, the voltage of the P wave tended to decrease. A significant increase in the R wave to +0.33±0.085 mV on day 7 of the study ($p < 0.05$), together with a tendency to decrease the S wave on days 7 and 30, indicate an improvement in the electrical activity of the ventricular myocardium. The R-wave, indicating ventricular activity, was well expressed in 55.6 % of animals on day 30 of the study. A 16.7 % decrease in the T wave voltage is evidence of an accelerated repolarisation phase (Table 9.4) [221, 245].

Table 9.4

ECG voltages of high-yielding cows with MCD after complex treatment in the dynamics of the study

Indexes		Intervals duration, sec			
		P-Q	Q-T	T-P	R-R
Before treatment (n=7)	Lim	0,15–0,25	0,26–0,35	0,16–0,31	0,57–0,77
	M±m	0,19±0,02	0,31±0,01	0,22±0,02	0,72±0,03
After 7 days (n=8)	Lim	0,16–0,2	0,21–0,34	0,17–0,28	0,64–0,75
	M±m	0,18±0,01	0,29±0,02	0,2±0,01	0,67±0,03
	p<	0,1	0,1	0,1	0,1
After 30 days (n=10)	Lim	0,12–0,21	0,29–0,39	0,2–0,47	0,69–0,92
	M±m	0,17±0,01	0,32±0,01	0,32±0,03	0,81±0,02
	p<	0,1	0,1	0,01	0,01

Note. p< – compared to the beginning of the research

An important characteristic of an electrocardiogram is the analysis of the duration of the main intervals: P-Q, T-R, Q-T and R-R, and the waves P, QRS and T. They reflect the dynamics of heart contraction, namely the duration of systole and diastole of the atria, ventricles and heart as a whole [91, 94, 96, 97, 142, 145, 216, 234, 244].

The use of complex therapy for the treatment of cows with myocardial dystrophy led to an increase in the duration of the cardiac cycle on day 60 ($p < 0.01$) to 0.81±0.02 s, which was accompanied by a probable prolongation of the total diastolic T-R ($p < 0.01$; Table 9.5).

In the structure of heart contraction, under the positive effect of cardiac glycosides of strophanthus, the absolute duration of atrial systole P-Q decreased, and ventricular systole Q-T, on the contrary, increased. Other parameters had insignificant fluctuations compared with the beginning of the experiment (Table 9.5).

Changes in myocardial conduction and rhythmicity of animals after complex treatment are better characterised by atrioventricular conduction and systolic parameters.

Table 9.5

Dynamics of ECG intervals duration in high-yielding cows with MCD

Indexes		Intervals duration, sec			
		P-Q	Q-T	T-P	R-R
Before treatment (n=7)	Lim	0,15–0,25	0,26–0,35	0,16–0,31	0,57–0,77
	M±m	0,19±0,02	0,31±0,01	0,22±0,02	0,72±0,03
After 7 days (n=8)	Lim	0,16–0,2	0,21–0,34	0,17–0,28	0,64–0,75
	M±m	0,18±0,01	0,29±0,02	0,2±0,01	0,67±0,03
	P <	0,1	0,1	0,1	0,1
After 30 days (n=10)	Lim	0,12–0,21	0,29–0,39	0,2–0,47	0,69–0,92
	M±m	0,17±0,01	0,32±0,01	0,32±0,03	0,81±0,02
	p<	0,1	0,1	0,01	0,01

Note. p< – compared to the beginning of the research

The ratio of the pulse transit time from the sinus node to the ventricles in relation to the R-R duration on day 60 of the study was 21.5±1.44% (13.4-27.8) and significantly decreased ($p < 0.01$) compared with the results before treatment (27.3±1.72% (22.1-33.5)). The Q-T/R-R ratio tended to decrease on day 30 to 39.4±1.85 %, compared with the pretreatment values of 43.0±1.51 % (see Fig. 9.12).

The use of complex therapy, where the main cardiotonic agent is cardiac glycosides of strophanthus, causes positive changes in the ECG of cows, which is manifested by a slight fluctuation in the voltage of the teeth, prolongation of the cardiac cycle and diastole, a decrease in atrioventricular conduction and an increase in the proportion of electrical systole Q-T in the structure of the cardiac cycle R-R.

In case of multiple heart and liver pathology, when changes affect not only the heart but also related organs, electrocardiogram changes are less pronounced. Thus, on the 7th day after treatment in animals with hepatocardial syndrome, a significant increase in the R wave voltage to 0.33±0.085 mV was found compared with the initial values ($p < 0.01$; Table 9.7). As in the treatment of animals with ICD, there was a tendency to increase the R-R interval by 13.0% on day 30 of the study due to the prolongation of the T-R systole by 28.6%. The duration of the P-Q and Q-T intervals did not change during the study period (Table 9.8).

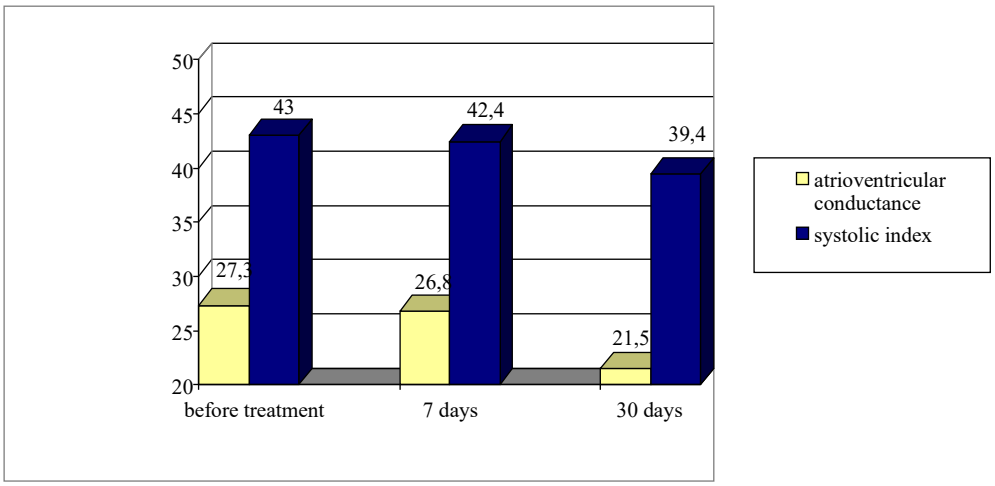

Table 9.12. Changes in relative atrioventricular conductance and systolic index in high-yielding cows with MCD, %

The use of complex therapy based on cardiac glycosides improves the passage of the impulse from the sinus node to the ventricles, i.e. relative atrioventricular conduction, which is 23.8±1.83 % (20.1-32.8) on day 30 of the study, compared with 27.2±1.21 % (23.6-33.8) – before treatment. The proportion of the Q-T interval in the R-R cardiac cycle had slight fluctuations on days 7 and 30 of the study and averaged 40.5±2.6% (32.8-50.0) and 41.0±1.26 % (35.5-46.1), whereas before the therapeutic intervention the systolic index was 42.7±1.98 % (35.3-51.9; Fig. 9.13).

It can be assumed that cardiac glycosides of strophanthus have little effect on myocardial contractility of high-yielding cows with hepatocardial syndrome.

The analysis of the electrocardiogram of cows showed that the use of complex therapy, which included cardiac glycosides of strophanthus, energy material (10 % glucose solution) and vitamins, helps to improve the main functions of the myocardium: conduction, rhythm, contractility, excitability in animals with myocardial dystrophy (Fig. 9.14) and to a lesser extent – with hepatocardial syndrome (Fig. 9.15).

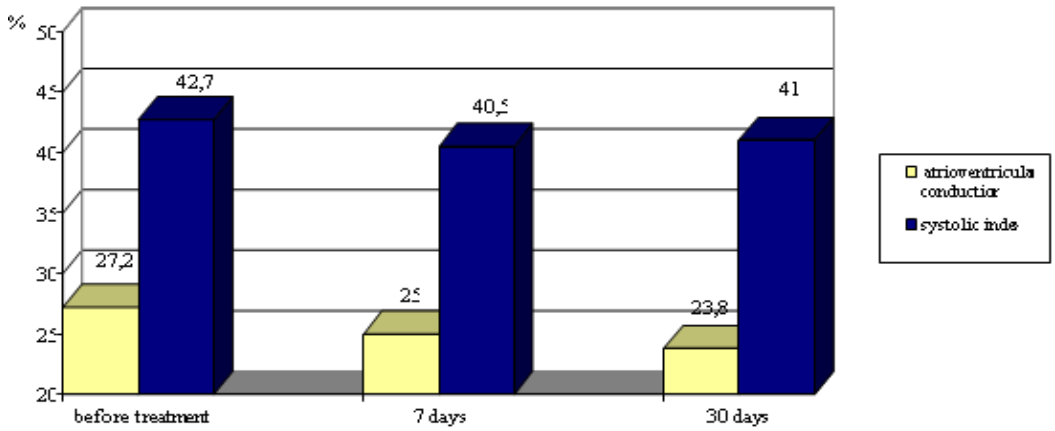

Figure 9.13. Changes in relative atrioventricular conduction and systolic index in high-yielding cows with hepatocardial syndrome

It can be assumed that cardiac glycosides of strophanthus have little effect on myocardial contractility of high-yielding cows with hepatocardial syndrome.

The analysis of the electrocardiogram of cows showed that the use of complex therapy, which included cardiac glycosides of strophanthus, energy material (10 % glucose solution) and vitamins, helps to improve the main functions of the myocardium: conduction, rhythm, contractility, excitability in animals with myocardial dystrophy (Fig. 9.14) and to a lesser extent – with hepatocardial syndrome (Fig. 9.15).

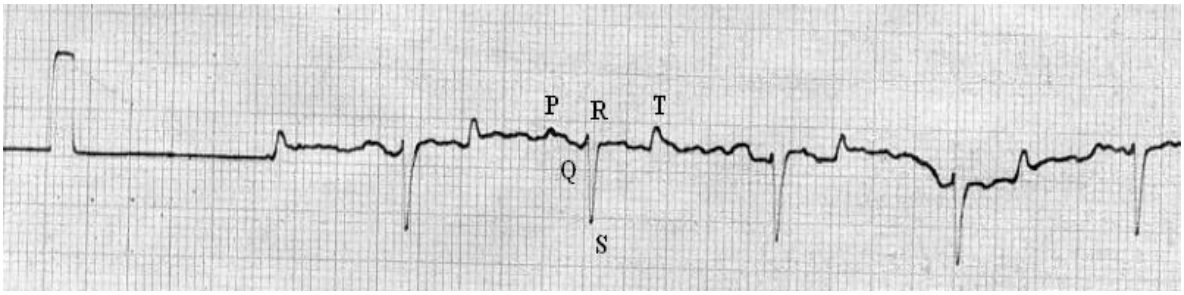

Figure 9.14. Electrocardiogram of a cow with mad cow disease on day 30 after treatment

The use of cardiac glycosides together with glucose and vitamin preparations helps to normalise the cardiac cycle by increasing the time for general rest of the heart muscle (Fig. 9.14, Fig. 9.15).

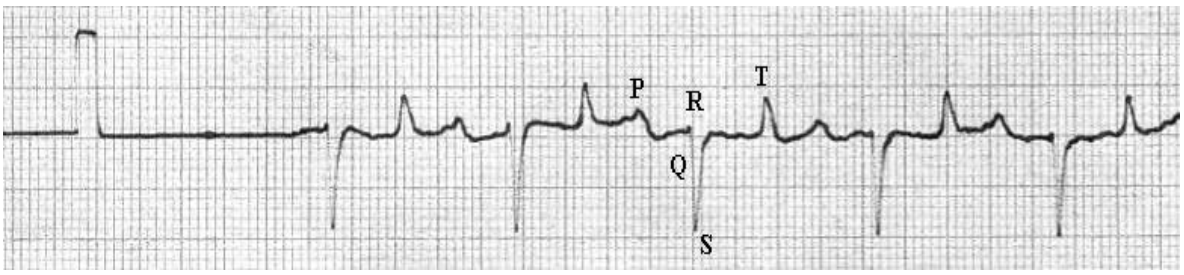

Figure 9.15. Electrocardiogram of a cow with hepatocardial syndrome, 30 days after treatment

Therapeutic measures aimed at improving the general condition of the organism were reflected in the improvement of milk production of the high-yield cows studied.

At the beginning of treatment, the daily productivity of clinically healthy animals was 20.6±1.83 (15.1-25.6); in cows with myocardial dystrophy – 25.1±1.43 (20.0-34.0); in patients with myocardial and hepatodystrophy – 18.3±3.48 kg (14.2-25.4) of milk of 3.2 % fat. The average daily yield per cow on the farm was 22 kg of milk. In 40 % of clinically healthy cows, 80 % of cows with myocardial dystrophy and 20 % with mixed pathology (hepatodystrophy and myocardial dystrophy), productivity was higher than the herd average. On the 60th day of the study, daily productivity in the group of cows with MCD and mixed pathology increased by 10.0 and 19.7 %, respectively, and amounted to 27.6±3.11 (24.1-32.7) and 21.9±0.81 kg (19.1-27.1) of milk, respectively (Fig. 9.16).

In addition to total milk production, milk fat and protein content are important economic indicators. In animals with myocardial dystrophy and hepatocardial syndrome, milk fat content tended to increase compared to clinically healthy animals. After complex treatment, in the 1st control group of cows, the fat content in milk tended to decrease, and in the second group, the opposite direction was observed. The protein content in milk of high-yielding cows of both control and experimental groups during 60 days of the study had insignificant fluctuations (table 9.7).

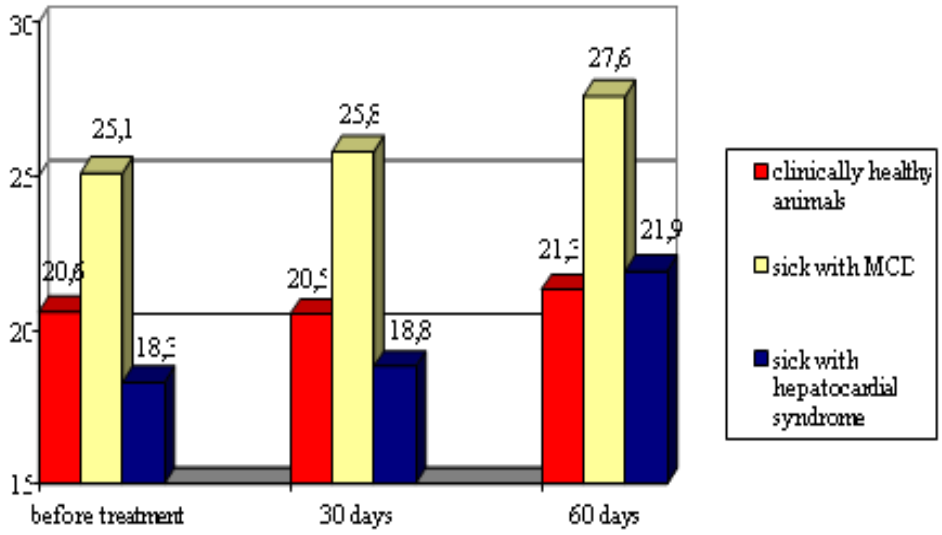

Figure 9.16. Dynamics of average daily milk production of high-yield cows

Table 9.7

Dynamics of fat and protein content in milk of highly productive cows

Indexes	Group of animals	Period of research		
		before treatment	30-days	60-days
Fat content, %	Control group	3,39±0,12	3,38±0,12	3,37±0,09
	1st group	3,4±0,1	3,36±0,1	3,31±0,09
	2nd group	3,42±0,11	3,43±0,1	3,45±0,11
Protein, %	Control group	2,88±0,1	2,93±0,1	2,88±0,09
	1st group	2,86±0,06	2,83±0,05	2,86±0,06
	2nd group	2,93±0,07	2,95±0,08	2,95±0,08

Note: experimental group 1 – cows with myocardial dystrophy; experimental group 2 – cows with hepatocardial syndrome

The use of a complex treatment regimen for cows with myocardial dystrophy and hepatocardial syndrome increased milk production by 10.0 and 19.7 %.

CONCLUSIONS

1. In clinically healthy high-yielding cows, the pulse rate is 60-80 beats/min; respiration – 14-30 respiratory movements/min; arterial blood pressure: systolic (SBP) – 100.0-140.0 mm Hg, diastolic (DBP) – 35.0-60.0 and pulse (PAP) – 53.0-93.0 mm Hg.

2. The electrocardiogram of clinically healthy high-yielding cows in the second frontal lead is characterised by the following indicators: cardiac cycle duration in the range of 0.76-1.19 s, including diastole – from 0.24 to 0.6 s, relative atrioventricular conductivity and systolic index are 11.5-25.0 and 25.7-47.4 %, respectively, P and T waves in all cows are electropositive (0.12-0.26 and 0.06-0.82 mV), in the ventricular QRS complex the S wave is best expressed (0.31-0.93 mV).

3. In clinically healthy high-yielding cows, the activity of total creatine kinase and its myocardial isoenzyme CK-MB is 10.0-80.0 and 1.0-20.0 U/l, respectively, the ratio of CK-MB/CK-NAC is 10, 0-40.0 %, the activity of total lactate dehydrogenase – 200.0-455.0 U/l, its myocardial isoenzyme LDH1 - 80.0-215.0 U/l, and the ratio of LDH1/LDH is in the range from 30 to 56 %.

4. Myocardial dystrophy is significantly widespread among high-yielding cows: the number of sick deep-calving animals is on average 55.1%, newly calved and early lactation – 50.6 % and 49.7 %, respectively. Most often, sick cows were detected with a productivity of more than 6000 kg of milk per lactation (50.1 %) and 24 kg per day (43.3 %).

The main causes of the pathology are an imbalance of diets in terms of nutrients and biologically active substances, cows with hepatodystrophy, ketosis, purulent necrotic processes in the limbs, and endometritis. A favourable factor is hypodynamia in tethered housing.

5. Diagnosis of myocardial dystrophy in high-yielding cows is based on the results of clinical and functional examination of the heart: tachycardia (82-98 beats. /min), weakening, amplification, splitting and bifurcation of tones (39.2; 30.9; 28.9 and 1.0 %, respectively), a decrease in systolic blood pressure, a

decrease in the duration of the cardiac cycle in 54.8 % of cows due to a decrease in the duration of diastole to 0.26±0.01 s in 51, 6 % of the affected animals (normal 0.24-0.6 s), an increase in relative atrioventricular conductance and systolic index by 4.1 and 4.2 %, negative T wave in the second lead in 18.7 % of cows.

6. Biochemical markers of myocardial dystrophy in high-yielding cows are increased activity of myocardial isoenzymes creatine kinase (CK-MB) in 79.3 % (5.5-121.1 U/l) and lactate dehydrogenase (LDH1) in 84.0 % of animals (111.0-485.0 U/l). The proportion of CK-MB in the structure of total creatine kinase activity was higher than physiological values in 66.0% (17.3-94.0%), and the ratio LDH1/LDH- in 85.3% of diseased cows (34.1-95.7%).

7. Hepatocardial syndrome is characterised by changes in the liver (hyperproteinemia – in 48.4 %; hypoalbuminemia – 95.2, positive results of sulemic and formic colloidal sedimentation tests – in 100.0 and 98.4, hepatomegaly – in 38.7 % of diseased animals, increased activity of AcAT – in 73.1 % of newly dehiscence cows and 58.3 % of cows in early lactation) and heart (tachycardia – 82-98 beats. /min; weakening, amplification and splitting of tones, reduction of systolic and pulse ACT). The electrocardiogram of sick cows is characterised by a decrease in the duration of the cardiac cycle due to diastole, an increase in relative atrioventricular conductivity and systolic index in sick animals by 6.0 and 2.5 %.

8. The activity of myocardial-specific isoenzymes – CK-MB and LDH1 – in cows with hepatocardial syndrome was increased, respectively, in 90.5 and 75.0 % of diseased animals with an average value of 31.9±3.78 and 231.6±3.78 U/l (in clinically healthy animals – 9.8±1.82 and 150.2+10.11 U/l). The ratio of CC-MB/CC-NAC was 53.6±2.96 %, LDH1/LDH – 65.7±1.65 %, which is significantly higher ($p < 0.001$) than in clinically healthy cows.

9. Comprehensive therapy of patients with myocardial dystrophy and hepatocardial syndrome in high-yielding cows (strophanthin-K; 10 % glucose solution, insulin, catozal and introvit) leads to a decrease in heart rate to 75±1.08 (72-80; $p < 0.001$) and 74±1.3 beats. /min (68-80; $p < 0.001$), optimisation of AKT, increase in cardiac cycle duration by 12.5 and diastole by 45.5% on day 30 from the

start of treatment, a significant decrease in the activity of cardiac-specific isoenzymes CK-MB by 59.7 and 19.7% ($p < 0.001$) and LDH1 by 34.2 and 27.4% ($p < 0.001$).

10. The restoration of liver function in cows with hepatocardial syndrome led to a significant increase in the amount of albumin, starting from day 7 of treatment ($p < 0.001$), and a decrease in the activity of AsAT and AlAT in the serum of animals on day 60 of the study.

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Scientific publication

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MYOCARDIUM DYSTROPHY OF HIGHLY PRODUCING COWS

Monograph

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