Ways of Increasing an Economic Efficiency of Dairy Cattle Breeding due to Expert Diagnostic Systems and Pharmacological Correction of Hepatopathies

M.P. Semenenko[1*], E.V. Kuzminova[1], K.A. Semenenko[2], R.A. Dyachenko[3], N.D.Kuzminov[3]

[1]FSBSI «Krasnodar Research Center for Animal Husbandry and Veterinary Medicine»,
Krasnodar, Russia
[2] FGBEI HE «Kuban State Agrarian University named after I.T. Trubilin»,
Krasnodar, Russia
[3]FGBEI HE «Kuban State Technological University», Krasnodar, Russia

Abstract
The article presents the results of research on the development of intravital diagnostics of liver diseases in cattle on the basis of bio-chemical profiles in hepatopathological conditions, as well as an experimental system that allows taking into account structured clinical and laboratory data and provides effective pharmacotherapy. The developed expert system makes it possible to conduct timely diagnostics of liver diseases of animals in order to control the effectiveness of therapeutic measures and predict the outcome of diseases of the hepatobiliary system. The results of the research contribute to an increase in the economic efficiency of dairy cattle breeding due to a higher return on therapeutic interventions, as well as an increase in safety of livestock and dairy products output.
Key words: economic losses, liver, dairy cattle, hepatopathies, expert systems, diagnostics.

INTRODUCTION

In recent years an economic development of individual branches of the national economy of the Russian Federation, especially livestock, is characterized by uneven profitability of the output of dairy products. Implementation in practice of intensive technologies of feeding and keeping of high yielding cows often leads to appearance of a discrepancy between the physiological capabilities of their organism and the actual parameters of feeding and keeping, due to the low adaptive potential. The emergence of pathologies under such conditions is manifested by the development of the metabolic syndrome, one of the most common forms of which can be deep dysfunctional changes in the hepatobiliary system. Liver diseases occupy a leading place in the overall structure of non-communicable diseases among dairy cows. This leads to a loss of calves and further loss of milk, which means that livestock holdings begin to incur huge economic losses [1, 2].

Liver is a central organ of the body homeostasis, which has a large functional reserve and has a good regenerative capacity. As a result, the emerging pathological processes in liver become noticeable and manifest clinically only in the progressing stages of the disease. Therefore, most hepatopathies are asymptomatic for a long time that makes it difficult to make a timely diagnose and develop effective pharmacotherapy. Without drawing attention to themselves, they progress, leading to dysfunction of various organs and systems, resulting in the loss of productive qualities of animals and high mortality [3].

The study of animals with presumed hepatobiliary disease is rather complicated, and a large number of parameters for assessing the condition of an animal require a consideration of all factors and a new approach to diagnosis. That is why the possibility of using computer information and analytical programs for liver diseases will give a possibility to a veterinarian to get rid of routine medical activities and to provide the opportunity for a deeper analysis of clinical information, and also to make decisions based on multivariate modeling followed by the introduction of optimal pharmacotherapy schemes into veterinary practice [4].

In this connection, the purpose of our research was the development of intravital diagnostics of liver diseases in cattle on the basis of biochemical profiles in hepatopathological conditions, as well as the development of an expert system that allows taking into account structured clinical and laboratory data, providing effective pharmacotherapy [5, 6].

METHODOLOGY OF RESEARCH

The studies were carried out on stale dry cows and heifers of the 7th and 9th months of pregnancy, as well as on lactating cows in different phases of the lactation period in the autumn-winter-spring periods, so during periods of greatest stress of the homeostatic systems of the body.

Complex clinical studies have identified animals with signs of metabolic disorders and liver pathology (n = 140), who have had a decrease in appetite, rare and lax chewing reflex, hypotension of the prednis, increase in

the percutaneous boundaries of liver, some tenderness during palpation, obesity (in some cases emaciation), signs of demineralization of bone tissue, which was accompanied by softening of the last caudal vertebrae and transverse processes of the lumbar vertebrae. A number of animals showed dullness and fragility of the wool cover.

After that, the animals were sampled for biochemical studies, including the determination of the total protein, protein fractions, urea, glucose, cholesterol, triglycerides, total bilirubin, hepatoindicator enzymes − alanine aminotransferase (ALT), aspartate aminotransferase (AST), gamma glutamyltranspeptidase (GGTP), alkaline phosphatase (AP) and the formulation of thymol test − colloidal stability test of protein components of blood.

Biochemical studies were carried out on an automated analyzer Vitalab Flexor Junior with the help of ELITech Clinical Systems kits.

In the development of the expert system machine learning methods were used, in particular the Python high-level language, its Scikit-learn library for constructing a probabilistic decision tree, the Pandas package for processing and analyzing data, as well as the javascript language and its Angular framework for building an interactive web application.

RESULTS

The obtained data of the biochemical profile of animals revealed significant changes in a number of indices. Thus, 70% of cows and practically all of the heifers had protein disorders showed abnormalities, manifested as a decrease and an increase in the level of total protein. On this background, shifts in the protein spectrum of the blood serum were registered, which, depending on the concentration of the total protein circulating in the blood, could be divided into two main types of proteinograms.

In the first case, the amount of albumin was reduced with hypoproteinemia. The level of γ-globulins remained within the limits of physiological boundaries. Concerning α- and β-globulins, certain animals showed certain fluctuations in the direction of increasing these fractions.

The observed abnormalities are characteristic for functional liver failure. Damage of the parenchymal structures, as a rule, leads to a decrease in its protein-synthetic function, which is accompanied first of all by a decrease in the level of albumins and more rarely by a decrease of beta-globulins.

The decrease in the functional activity of liver hepatocytes led to a weakening of other synthesis-forming processes in them. An analysis of the blood levels of such animals revealed a decrease in the level of glucose, triglycerides (energy-providing function) and urea (urea generation function). At the same time, the activity of the studied enzymes − transaminase, GGTP and AP were within the limits of the lower values of the species norm, which can serve as an indirect confirmation of the presence of destructive changes of hepatocytes, as a result of which the ferment-forming function of the liver was weakened.

In the second case, hypergamma-globulemia (from moderate to high) was registered in the protein exchange of the studied animals on the background of increased values in the concentration of the total protein, which was accompanied by hyperfermentation due to an increase in the activity of serum transaminases belonging to the group of indicator enzymes and therefore having an important diagnostic value in hepatopathies.

In animals with similar homeostatic changes the level of AST was increased on the average by 28-63% of the upper limits of the norm; ALT was increased by 33-87%. As for GGTP, its increase was moderate and was not noted in all cases.

The irritation of the reticuloendothelium and, in particular, the system of mononuclear phagocytes, as well as the concomitant mesenchymal inflammatory syndrome, leading to an increased synthesis of the gamma-globulin fraction (that belongs to a coarsely dispersed fractions), causes a decrease in the colloidal resistance of proteins. In this case, the use of colloid resistance tests allows detecting changes in the shifts in the serum protein range. Therefore, the most informative indicator in animals with this biochemical profile was the positive thymol test in 100% of cases, which allowed us to diagnose "hepatic parenchyma inflammation syndrome".

The remaining biochemical indicators were either within the normal values (glucose, urea, cholesterol − not always), or had moderate downward deflections (triglycerides and alkaline phosphatase).

In 10% of cases in the study of a number of indicators in the examined animals a cholestatic syndrome was found out. The main biochemical changes were observed in the following indicators:

- protein metabolism − moderate hypergamma-globulinemia (the number of γ-globulins exceeded the upper limits of the norm by 13,7-17,8%);
- lipid metabolism − expressed hypercholesteremia (cholesterol level increased in 1,52-1,84 times);
- pigment metabolism − hyperbilirubinemia, characterized by a high level of bilirubin, in 2-2,8 times higher than the upper abdominal values;
- enzyme exchange − a significant increase in GGTP and alkaline phosphatase at a quiet level of transaminases − AST and ALT. Such a picture in the biochemical parameters indicates that during intrahepatic cholestasis (violations secretion and bile flow from the hepatocytes) epithelial bile duct cells are pressed and destructed (note that GGTP is contained in the epithelial cells that line the biliary tract and hepatic ducts, and alkaline phosphatase − in the parenchyma and the walls of the bile ducts of the liver, and that therefore are most sensitive laboratory parameters in diseases of the hepatobiliary system, so-called, markers of cholestasis).

In some cases, there may be a moderate increase in serum aminotransferases due to an increase in the permeability of plasma membranes of hepatocytes, however, outside the stage of exacerbation such hyperfermentation does not have a clearly expressed manifestation.

Finally, in some serum samples from the examined animals we found an increase in the activity of a number of indicator of liver enzymes (AST, ALT) and bilirubin (in 1,58-2,75 times) without an inflammatory process from the γ-globulin fraction of the protein spectrum and thymol sample. A similar pattern arises from the disruption of the cell structure and the integrity of the hepatocyte membranes caused by exogenous or endogenous toxic liver damage (mycotoxins, substandard and spoiled feeds, nitrates, nitrites, urea, as well as under-oxidized intermediates − proteinogenic amines, guanidine derivatives, ketone bodies, acetone, acetoacetic, β-hydroxy-butyric acid).

Our studies have shown that hepatopathological conditions that arise in highly productive dairy cattle can be conditionally divided into four biochemical profiles characterized by the following syndromatics:

1. Syndrome of hepatic-cellular insufficiency − a violation of the synthetic function of liver with a decrease in the level of a number of indicators − albumins, glucose, urea, cholesterol, triglycerides.

2. Inflammatory syndrome − an increase in γ-globulins, thymol sample, levels of AST and ALT.

3. Syndrome of cholestasis (excretory-biliary) − an increase in alkaline phosphatase, GGTP, bilirubin, cholesterol.

4. Syndrome of integrity of hepatocytes (cytolysis, impaired permeability of hepatocyte membranes) − an increase in the parameters of ALT, AST, bilirubin.

On the basis of these data, new approaches have been developed to solve diagnostic and pharmacotherapy problems of liver diseases in dairy cattle, including an expert system that allows determining correctly liver pathology based on hepatological profiles and prescribing the most effective treatment, as well as forecast the outcome of treatment of the disease and prevent complications.

DISCUSSION

It should be noted that progress in this direction has been achieved in humane medicine, where a large arsenal of diagnostic methods has been proposed and tested for the study of liver status and the syndrome of diseases has been developed. In veterinary medicine, however, such a principle has not yet been developed. The proposed system of using the most informative indicators that are necessary for diagnosing a particular liver disease, which are grouped into so-called profiles, or biochemical research programs, increases the effectiveness of the integrated approach to diagnosing liver diseases in animals based on the principles of evidence-based medicine.

Another aspect that determines the novelty and innovative essence of the conducted studies is the absence of expert systems for diagnosing liver diseases or the normal state of a sick animal for a combination of proven correlation-dependent parameters with subsequent recommendations for the most effective treatment in veterinary medicine [7, 8].

CONCLUSION

Thus, on the basis of experimental data, biochemical profiles of hepatopathological conditions in dairy cattle have been determined, and an expert system has been developed that allows making timely diagnostics of liver diseases in animals in order to monitor the effectiveness of therapeutic measures and predict the outcome of diseases of the hepatobiliary system. The results of the research will contribute to increasing the efficiency of production of dairy cattle through the development of scientific approaches, methods, economic models, as well as higher return of therapeutic and preventive measures.

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