Methodology of development and diagnostic efficiency of expert systems in animal hepatopathies

M P Semenenko, E V Kuzminova, K A Semenenko and N D Kuzminov

Krasnodar Research Centre for Animal Husbandry and Veterinary Medicine, Krasnodar, 350055, Russia

E-mail: sever291@mail.ru

Abstract. The article discusses the issues of improving the diagnosis of liver pathologies using an expert system - a computer program that allows considering a number of clinical and laboratory data obtained during the treatment of animals. This system will make it possible to conduct a deep information analysis with the subsequent implementation of the forecast for the risks of developing hepatopathies in cattle with the recommendations for reducing the occurrence of diseases.

1. Introduction

One of the essential elements of modern agricultural policy is the introduction of intensive forms of livestock breeding. Along with high productivity, increase the biological requirements of animals to the conditions of maintenance, quality and feeding technology, the non-observance of which leads to the development of metabolic disorders and liver function disorders. Currently, hepatopathies occupy up to 25% of all non-contagious diseases in animals; in highly productive dairy cattle, they are registered in 30-60% of animals [1].

The question of diagnosis of liver pathology in veterinary practice is considered quite complicated that is explained by the variety of functions and the huge reserve potential of this organ. Liver takes central stage in the processes of all types of metabolism, digestion, as well as in the processes of detoxification of the animal organism. In this case, the hepatic parenchyma is characterized by the great regenerative ability, and in the conditions of the pathology development, new healthy cells are formed quite quickly; they begin to function actively and disguise the development of the disease. In this connection, pathological processes, arising under the influence of various factors in liver, become noticeable and manifest clinically only in the progressive stages of the disease, which makes it difficult to diagnose and develop effective treatments for hepatopathies in time [2, 3].

One of the promising ways of the development of the diagnosis process, differential diagnosis and prediction of liver diseases is the use of information technology, which is understood as a set of methods and means of obtaining and using information based on computer and communication technology using mathematical methods [4].

Modern artificial intelligence systems with the knowledge of highly qualified specialists have increasingly act as electronic experts. In veterinary medicine, the introduction of specialized expert systems will intensify the work of veterinarians due to a more accurate and quick diagnosis, as well as increase the methodological level of medical and preventive measures of veterinarian specialists [5].
One of the progressive directions in this area is the development of diagnostic algorithms using multidimensional statistics and the construction of a functional mathematical model that connects the numerical values of indicators with an integrated assessment of the state of the body. Mathematical models are quantitative laws that describe generalized indicators of the state of an organism (organ), which are the criteria for intergroup differences \( Z_{1-2} \), as well as the criteria for differential diagnosis in comparable groups (in our case, \( Z \) - healthy / sick or \( Z \) - hepatitis / hepatosis and other).

2. Discussion
In the Russian Federation in the field of veterinary medicine, mainly automated epizootological monitoring systems on the basis of the Veterinary Department of the Ministry of Agriculture of the Russian Federation are presented. The majority of expert computer programs have been developed for practical health care: systems for the diagnosis and treatment of arterial hypertension, myocardial infarction, steatosis and liver fibrosis, etc. However, the use of these systems for making decisions in the differential diagnosis of liver diseases in animals is not possible, since fundamentally different approaches to the interpretation of data in relation to the field of veterinary medicine (productivity, mycotoxicological profile of feeds, etc.) have not been taken into account.

As for foreign software, there are mainly programs for the management of veterinary clinics predominate and expert systems for animal diseases focus on unproductive animals (dogs, cats).

These expert systems are not intended to make decisions in the diagnosis of liver diseases in dairy cattle, to select the optimal treatment regimen and prophylaxis, as well as to predict the risks of developing hepatopathologies in animals for the specific livestock farm.

In this connection, the aim of the research was to develop a new software product for solving the problems of diagnosis, treatment and prevention of liver diseases in dairy cattle.

3. Methodology
One of the main stages in developing a diagnostic model is the procedure for selecting the most informative indicators to increase the level of diagnosis and the effectiveness of treatment for liver diseases in cattle. According to the results of many years of research conducted at the Krasnodar Research Veterinary Institute, an algorithm for the diagnosis of hepatopathies has been developed, which include anamnestic, clinical, laboratory, instrumental and morphological studies [6].

At diagnosis of liver pathology, the anamnesis is of great importance, which gives the veterinarian specialist the information about the animal’s life preceding the disease, vaccinations, etc. The main reason for the development of hepatosis in high-yielding dairy cattle is most often unbalanced and poor-quality feeding of animals, therefore, when assessing the anamnesis information, it is necessary to take into account the structure of the ration, the quality of feed, as well as the presence of mycotoxins in them.

In the proposed research algorithm, when diagnosing liver pathology, special attention is paid to the determination of both qualitative and quantitative composition of mycotoxins in feed. In this case, attention should be paid to the combination of these toxicants even in concentrations not exceeding the determined maximum permissible levels (MPL), as a possible etiological factor in the development of hepatopathy. The presence of several mycotoxins in feed enhances and prolongs their negative effect on the animal organism, and since the liver is the primary target organ, it leads to its damage [7].

In the developed expert system for formation a diagnostic model for hepatopathies in cattle, the filling tab is proposed in the “database” block, which will allow assessing the quality of the structure of the ration used in the farm. When developing an expert system aimed at diagnosing diseases, these data are relevant, since the most common “fatty liver” syndrome often occurs because of a lack of amino acids, vitamins and minerals in feed, and a violation of the sugar-protein ratio. After filling the data into the program, the user will be offered conclusions and, if necessary, recommendations for adjusting the composition of the ration in order to reduce the risk of developing liver diseases in the livestock [8].
Biochemical research methods are often fundamental in the diagnosis of liver diseases. In animals, blood is sampled for laboratory tests taking into account the hepatological profile, which includes the determination of the most informative biochemical parameters [6, 9].

Hepatopathological conditions can be divided into four biochemical profiles with specific syndromatics (table 1).

| Table 1. Biochemical profiles in hepatopathology. |
|-------------------------------------------------|
| Hepatic Cell Disorder Syndrome | Violation of the synthetic function of liver with a decrease in the level of albumin, glucose, urea, cholesterol, triglycerides |
| Hepatocyte Integrity Disorder Syndrome (cytolysis, impaired hepatocyte membrane permeability) | Increase of ALT, AST, bilirubin |
| Cholestasis Syndrome (excretory-biliary) | Increase of alkaline phosphatase, gammaglutamyl transpeptidase, bilirubin, cholesterol |
| Inflammatory Syndrome | Increase of γ-globulins, thymol test, AST and ALT |

Blood biochemical parameters are the most informative, but pathological conditions of liver inevitably affect the parameters of the general blood test, often showing a discrepancy with the norm. To clarify the diagnosis of hepatopathology, it is necessary to evaluate the following blood factors - leukocytes, erythrocyte, hemoglobin, platelets and erythrocyte sedimentation rate. The level of liver function can also be determined by the results of laboratory analysis of urine, in which the diagnostic markers are its color, consistency, pH, and the presence of extraneous compounds.

Palpation of liver is an important method of clinical examination. The low location of the lower edge of the liver indicates its increase, which can be differentiated using percussion determination of the upper border. Medium liver soreness during palpation can be observed at hepatitis, severe liver soreness can be observed at purulent processes. The determination of the size of the spleen is important, because with some liver diseases, it can be increased (for example, acute hepatitis).

For the diagnosis of liver pathology the conditions of the fur and skin, the presence of icterus (coloring of skin and mucous membranes in different shades of yellow), body temperature are of a great importance.

Ultrasound examination is a method that has proven itself as an accurate way to study the condition of internal organs. Using an ultrasound scanner, a specialist can differentiate various pathologies, as well as determine the best places for a biopsy. The condition of liver in animals is evaluated by the following criteria - position, size, shape, uniformity, echogenicity, clear boundaries, and state of the vascular pattern, capsule and gall bladder. The study of these indicators allows veterinarian specialists to establish the features of the ultrasound image for various nosological units of liver diseases and to make the correct diagnosis [10].

As additional tests, immunological research methods are used for the specific diagnosis of diseases of an infectious and parasitic nature, as well as for predicting the course and outcomes of a number of pathologies.

At mass diseases of cattle in livestock breeding farms, the diagnosis of hepatopathology is confirmed by the results of a comprehensive postmortem examination of dead and slaughtered animals, as well as histological examination of liver samples.

To solve the problems of optimizing early diagnosis and effectiveness of treatment at liver diseases in cattle as diagnostic methods for evaluating the development and degree of pathological processes in hepatocytes, we proposed a method for determining the level of endogenous intoxication in the body by evaluating the concentration of medium mass molecules (MMM) in blood of healthy animals and animals with liver pathology of various genesis. To assess the pronounced degree of indicators of
MMM in hepatopathological conditions from probabilistic-statistical methods, linear regression analysis was used that made it possible to determine statistically significant relationships, as well as to predict unknown values of the resulting indicators, to identify causal relationships between explanatory variables and resulting indicators. Therefore, the direct relationship was found out between the concentration of MMM in the blood and the severity of the pathological process. A persistent increase in the level of MMM in liver pathology, despite the improvement of a number of biochemical parameters, can be a sign of an adverse outcome of the disease and allows adjusting the applicable treatment regimen. In animals diagnosed with chronic liver pathology, regular determination of the level of MMM during the period of remission allows to predict the development of relapse and to conduct the preventive therapy [11].

All of the above criteria for diagnosing liver pathology in cattle are designed in the expert system “Diagnosis of liver diseases in cattle”, where they are presented in the form of modules of the knowledge section embedded in the system.

4. Results

The result of this stage of research was a machine learning model, ready for the use in an expert system. During the development of this model, some machine learning software tools and four machine learning models were analyzed that allow making multiclass classification. Eight major liver diseases in dairy cattle such as acute hepatitis, chronic hepatitis, acute hepatosis, chronic hepatosis, acute fascioliasis, chronic fascioliasis, acute cholelithiasis and chronic gallstone disease were also analyzed.

Based on the analyzed diseases, training and test samples were compiled. The structure of the obtained samples is presented in table 2. It is assumed in the table that N – is the number of the last animal, C – is the symptom, B – is the disease index.

Table 2. Disease table structure.

| № | C1 | C2 | … | C72 | B |
|---|---|---|---|----|---|
| 1 | 1 | 0 | … | 0.2 | 1 |
| … | … | … | … | … | … |
| N | 1 | 1 | … | 0.7 | N |

Each row of the table is a model of a real animal, in which you can see 72 indicators and the diagnosis based on these indicators. The columns of the table are responsible for certain indicators, such as wet cough, pulse, temperature, and others. The sample contains both binary data and continuous data.

These samples allowed making the learning of models, as well as making choices of the model that is most suitable for the set goals. After learning the models, a comparative analysis of the results was carried out. Scikit Learn provides various assessment metrics to evaluate quality. The default score is the accuracy metric, which is calculated using the following formula:

\[
\text{accuracy} = \frac{TP + TN}{TP + TN + FP + FN}
\]

where TP - true positive result (TruePositive);
TN - true negative result (TrueNegative);
FP - false positive result (FalsePositive);
FN - False Negative (FalseNegative).

Figure 1 shows the test results of four trained machine learning models using the accuracy metric.
Based on these results, we can conclude that at the moment, the Naive Bayes model has shown the best result. In addition to this, the model is one of the simplest and fastest. In the future, it is possible to normalize the data, which will increase the accuracy of all models. With the available samples, the Naive Bayes method is the best for use in the expert system “Diagnosis of liver diseases in cattle” for the use in developing a software implementation.

This model was implemented in an expert system.

To develop the graphical interface of the expert system, the PyQt5 graphical framework was used together with the graphic interface designer QtDesigner. Work with these tools is carried out in Python.

The application consists of a single window and a pop-up dialog informing the result of the prediction. The main application window contains a form and one button. The form contains 74 fields of two types: a field for entering a test and a flag button of the yes / no type.

The user needs to fill in the form fields with data reflecting the state of the animal. After filling in all the fields, you should click on the “Get Results” button. A dialog box appears in which the diagnosis is presented, as well as recommendations for treatment and prevention.

5. **Conclusion**

The expert system “Diagnosis of liver diseases in cattle” will optimize the work of veterinary specialists due to:

- increase the efficiency of diagnosis;
- providing data on the modern methodology of prevention and treatment;
- transfer of knowledge of leading veterinary specialists to medical practitioners, due to the concentration and constant updating of reference information;
- prediction of the risks of hepatopathology in animals, with the recommendations to reduce the occurrence of the disease.

The software product is intended for use by veterinarian specialists at livestock breeding enterprises, farms, employees of agricultural information and advisory services, and can also be used...
in the educational process of specialized educational institutions, in the advanced training system for veterinarians.

Thus, based on the conducted studies in order to increase the level of diagnosis and the effectiveness of treatment of liver diseases in cattle, a diagnostic algorithm is made and the main markers of hepatopathological conditions that occur in dairy cattle are determined and an expert system is developed. The research results will contribute to increasing the efficiency of the dairy livestock industry by improving the quality of treatment measures, as well as increasing the safety of the livestock and the yield of dairy products.

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