The software complex for biochemical indicators monitoring taking into account ecological background of the region

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Abstract. This article is devoted review the process of using new methods of hypertonic disease monitoring. The authors suggest to use patient’s immunological and biochemical homeostasis for predicting and diagnosis this disease. It is proved that these data can be used for monitoring and controlling patients. The correlation between immuno-biochemical parameters and the ecological background patient’s place of residence are set. The problem of the design and construction of specialized complex laboratory control based on client-server architecture is considered. For data analysis supposed to be used statistical and intellectual processing methods. For example, in article describes the basic classification algorithm called “k nearest neighbors”. When the size of “training sample” is sufficient the accuracy in determining the class label reaches 99%. In conclusion emphasizes the importance of developing methods for early diagnosis of cardiovascular disease and using the modern methods for data analysis.

1. Introduction

Currently, there is a problem of increasing the number of cardiovascular diseases. According to international experts today, about 1 billion people suffer from a persistent increase of blood pressure in the world and about 7.1 million deaths per year are associated with increased blood pressure [5]. Huge prevalence determines significance of early diagnosis of this disease.

To automate the work of clinical diagnostic laboratories, laboratory information systems (LIS) are created, which are an independent class of complex software systems that support the main business processes of laboratories. Such systems allow to improve the quality of patient care by reducing the number of errors and the length of research, creating laboratory control and management tools, increasing the productivity of prevention and treatment facility (PTF) personnel, and forming a single information space. Also, LIS should help in ensuring early detection of changes in the human body that can lead to the disease. This can be achieved both by developing methods for diagnosing diseases and by improving tools and systems for processing medical data.

Thus, the direction of LIS development is to expand the composition of user functions to provide information support for special research processes, in particular, immuno-biochemical ones related to the study of the functioning of the humoral immunity system. The modern approach to the selection of laboratory assessment of the state of homeostasis disorders determines the relevance of immuno-biochemical monitoring.
2. The level of formation of natural antibodies (NAbs) to bioregulators
In addition to traditional means, the development of a new scientific direction of biochemistry intensively developing in the last decade, associated with the study of the functioning of the humoral immune system, for example, the synthesis of autoantibodies to neurotransmitters [1,3,4], can be used to monitor patient performance. In particular, measurements of such indicators as the determination of natural antibodies to β-endorphin, histamine, bradykinin, dopamine, serotonin are used to monitor hypertensive diseases. It is important to consider the effects of the environment on the human immune system.

In connection with the relevance of patients with cardiovascular diseases condition monitoring, a specialized complex of laboratory control of immuno-biochemical homeostasis is proposed, taking into account the environmental background of the patient's region of residence. The use of such a complex is a priority direction of technology for assessing the impact of endogenous and exogenous risk factors on health.

Previously, the relationship of generally accepted laboratory indicators and immunological parameters was established, reflecting the violation of regulatory function systems at the level of formation of natural antibodies (NAbs) to bioregulators in the serum of patients with hypertension [1,2,3].

Figures 1-5 show graphs of NAbs levels to neurotransmitters of the patients control group who do not have hypertensive disease and patients diagnosed with hypertensive disease.
The graphs show a clear excess in hypertensive patients compared to the control group. The difference is 30-50%.

Additional criteria for assessing the state of patients with hypertensive disease may be indicators of the environmental background of the place of residence of patients, in particular, exceeding the maximum permissible concentration of harmful substances in atmospheric air [4,5] (table 1).
Table 1. Concentration of harmful impurities in atmospheric air in places of residence of patients with cardiological pathology.

| detrimental impurities     | Atmospheric Air Content (mg/m³) |
|-----------------------------|---------------------------------|
|                            | Post 1  | Post 3  | Post 7  | Post 8  |
| hydrogen sulfide            | 0.01    | 0.01    |         |         |
| formaldehydes               | 0.012   |         |         |         |
| Benzo[a]pyrene              | 0.046   |         |         |         |
| phenol                      | 0.006   | 0.0063  |         |         |
| hydrogen chloride           | 0.065   |         |         | 0.065   |
| sulfur dioxide              | 2.08    |         |         |         |
| Nitrogen dioxide and oxide  | 0.08    |         |         | 0.08    |

Observations of atmospheric air pollution in Penza are carried out at four stationary posts of the State Observation Service (SOS). Posts are conditionally divided into "urban background" in residential areas (posts 1 and 8), "industrial" - near enterprises (post 7) and "auto," near highways or in areas with heavy traffic (post 3).

These pollutant concentrations were obtained by means of air pollution control equipment (APC), namely automatic gas analyzers [6].

The average degree of correlation between e-AT synthesis to neurotransmitters in blood serum and priority environmental pollutants was revealed (tables 2-5).

Table 2. Correlation of e-AT to neurotransmitters at post 1.

|                               | NAbs level to β-endorphin | NAbs level to dopamine | NAbs level to serotonin | NAbs level to histamine | NAbs level to bradykinin |
|-------------------------------|---------------------------|------------------------|-------------------------|-------------------------|--------------------------|
| NAbs level to β-endorphin     | 1                         |                        |                         |                         |                          |
| NAbs level to dopamine        | 0.5                       | 1                      |                         |                         |                          |
| NAbs level to serotonin      | 0.4                       | 0.5                    | 1                       |                         |                          |
| NAbs level to histamine       | 0.5                       | 0.2                    | 0.1                     | 1                       |                          |
| NAbs level to bradykinin      | 0.5                       | 0.2                    | 0.2                     | 0.2                     | 1                        |

Table 3. Correlation of e-AT to neurotransmitters at post 3.

|                               | NAbs level to β-endorphin | NAbs level to dopamine | NAbs level to serotonin | NAbs level to histamine | NAbs level to bradykinin |
|-------------------------------|---------------------------|------------------------|-------------------------|-------------------------|--------------------------|
| NAbs level to β-endorphin     | 1                         |                        |                         |                         |                          |
| NAbs level to dopamine        | 0.4                       | 1                      |                         |                         |                          |
| NAbs level to serotonin      | 0.5                       | 0.6                    | 1                       |                         |                          |
| NAbs level to histamine       | 0.4                       | 0.4                    | 0.4                     | 1                       |                          |
| NAbs level to bradykinin      | 0.5                       | 0.7                    | 0.6                     | 0.5                     | 1                        |
Table 4. Correlation of e-AT to neurotransmitters at post 7.

|                | NAbs level to β-endorphin | NAbs level to dopamine | NAbs level to serotonin | NAbs level to histamine | NAbs level to bradykinin |
|----------------|---------------------------|------------------------|-------------------------|-------------------------|--------------------------|
| NAbs level to β-endorphin      | 1                         |                        |                         |                         |                          |
| NAbs level to dopamine          | 0.5                       | 1                      |                         |                         |                          |
| NAbs level to serotonin         | 0.2                       | 0.5                    | 1                       |                         |                          |
| NAbs level to histamine         | 0.4                       | 0.4                    | 0.4                     | 1                       |                          |
| NAbs level to bradykinin        | 0.6                       | 0.2                    | 0.2                     | 0.5                     | 1                        |

Table 5. Correlation of e-AT to neurotransmitters at post 8.

|                | NAbs level to β-endorphin | NAbs level to dopamine | NAbs level to serotonin | NAbs level to histamine | NAbs level to bradykinin |
|----------------|---------------------------|------------------------|-------------------------|-------------------------|--------------------------|
| NAbs level to β-endorphin      | 1                         |                        |                         |                         |                          |
| NAbs level to dopamine          | -0.4                      | 1                      |                         |                         |                          |
| NAbs level to serotonin         | 0.2                       | 0.2                    | 1                       |                         |                          |
| NAbs level to histamine         | -0.5                      | 0.2                    | 0.2                     | 1                       |                          |
| NAbs level to bradykinin        | 0.2                       | 0.3                    | 0.2                     | 0.2                     | 1                        |

3. The intelligent processing based on k-nearest neighbours algorithm

Study execution diagram is discussed in detail in [7,8]. It is advisable to select data preparation and processing units for analysis (figure 6).

The metrics mining unit perform statistical processing of personal diagnostic results according to specified methods, including estimation of trends in changes in values of estimated metrics and
considered factors, and intelligent processing based on machine learning algorithms, for example, the k-nearest neighbours algorithm, which is used to classify objects. The main principle of the k-nearest neighbors algorithm is that the object is assigned to the class that is most common among the neighbors of this element. The algorithm is implemented in Python and, with a sufficient number of "training" data, shows almost 100% accuracy (figure 7). The "proximity" of the elements was determined using the Euclidean metric.

Figure 7. Implementation of the k-nearest neighbors algorithm in Python language.

4. Conclusion

It is proposed to implement the software complex based on the client-server architecture, with a thin web client, the advantage of which is:

- use only a web browser;
- elimination of dependence on installed operating system (reduction of cost of required systemwide software);
- possibility of building a complex based on freely distributed software.
- The software package under development will allow:
  - develop and improve laboratory control of immuno-biochemical homeostasis in hypertensive patients;
  - explore the possibility of using formal models to ensure the reliability of assessments of the functional state of organs and systems;
  - reduce the length of the analysis process;
  - early detection of pathological changes in immuno-biochemical status based on monitoring of accumulated data.

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