Development of algorithms for diagnosing forms of lichen planus and predicting of the disease's course

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Abstract

The work is devoted to application of mathematical methods and development of algorithms for diagnostics of the lichen planus forms that located at mucous membrane of the mouth and lips, the differential diagnosis of severe forms of other diseases and its prediction in difficult cases through the use of expert knowledge base, the results of the selection of the most informative features and micronucleus test's interpretation in buccal epithelium.

Keywords: lichen planus; differential diagnosis; Kohonen neural network

1. Introduction

Diagnosis of lichen planus that located at the oral mucosa and the vermilion border has a significant interest among dentists, dermatologists, oncologists and doctors of other specialties. This is due to the lack of clear mechanisms of the disease development, severe, often permanent period, the existing trend towards malignancy elements of destruction, as well as frequent interaction with the General condition of the patient.

Treatment of patients applying for dental care with pathology of the oral mucosa and lips, is one of the most challenging problems in dentistry because of the difficulties that occur by diagnosis of diseases in this body's region. For example, the survey of 214 dentists, students of the improvement series in the Stomatology Department of the supplementary professional education Institute, Voronezh state medical University named after N. N. Burdenko, showed that only 30% of them are trying to make a diagnosis and prescribe treatment in cases of pathology of the oral mucosa and lips, and the remaining 70% of physicians send patients to the relevant medical Department of the University.

Analysis 568 advisory directions to the Department from dentists of the city's hospitals and region shows that the most often reveals of the discrepancy in the diagnosis of diseases such as lichen planus, various forms of cheilitis, erosive-ulcerative lesions of the oral mucosa, glossalgia. During the complex examination of patients by the Department staff revealed that the differences in the diagnoses at referral and the final diagnosis was 28%. In this regard, to improve the treatment of lichen planus of the oral mucosa and the vermilion border relevant has been the development and implementation of the educational and clinical practice of the Department by the algorithm computer system which allows on the basis of the most essential signs to diagnose forms of the disease, differential diagnosis with other diseases, to give the treatment regimen.

2. Methods

Due to the fact that the experience of our clinic covers almost a quarter of the observations' century, we can state the fact that the incidence of misdiagnosis has no tendency to decrease for years. This is despite the fact that in the literature, including and intended for dentists issues of clinical laboratory diagnostics of the diseases is paid more attention from year to year.

The authors analyzed clinical and laboratory characteristics of lichen planus, established expert knowledge base, the selection of the most informative parameters (erosive and ulcerative elements, the presence of local irritating factors, the presence of inflammatory infiltrate at the base of erosions, ulcers, nature of complaints, the course of the disease, age and gender of the patients, favourite localization, lesions of the skin, the reaction of the lymph nodes, the possibility of malignancy, specific characteristics, General condition), on the basis of which the basic principles of differential diagnosis of lichen planus with other diseases of the oral mucosa and lips was put forward.

The most common form was in the sample of 212 patients with the typical one (45,7%). Exudative-hyperemic form of lichen planus was diagnosed in 19,3%, erosive – 24,5%, bullous form – at 3.8%, erosive-ulcerative – 6.6% of patients. Significant difficulties in the diagnosis of lichen planus associated with the definition of severe forms of the disease. In determining of the criteria for identifying severe forms of lichen planus took into account the following: prevalence of the process on the mucous membrane of the mouth and lips, duration, and frequency of exacerbations, length of remissions, the severity of subjective sensations (pain), the effect of previous standard therapies, changes in the quality of life of patients.

The algorithm provides two basic modes of operation:

1) using the results of the micronucleus test in buccal epithelium, which informs the patient of lichen planus, and further work on determining the shape of disease and prediction of flow depending on the shape;

2) differential diagnosis of lichen planus with diseases such as ulcus decubitalis ulcers with signs of hyperkeratosis, trophic ulcers with signs of hyperkeratosis, leukoplakia and erosive forms of chronic lupus erythematosus, pemphigus vulgaris,

ulcerative-necrotic stomatitis, exudative erythema multiforme, recurrent aphthous stomatitis, and then in identifying of lichen planus implementation of the transition to the first mode.

In addition, in the reference part of the algorithm provides a practical introduction to the dentist with a full description of the knowledge base in the field of diagnostics of lichen planus forms and differential diagnosis with appropriate illustrations from the auther's own clinical observations.

Micronucleus test in buccal the epithelium of the oral cavity is one of the most widely used methods for the evaluation of genetic homeostasis, because of its quickness, easiness, non-traumatic, cost-effective, allowing you to survey an unlimited number of times, requires no special equipment for cultivation of cells [1]. Practical introduction dentists can significantly improve the diagnostic level of lichen planus.

It should be noted that currently, often for the differential diagnosis of severe diseases and classification of their forms use neural networks, which are attractive from an intuitive point of view, because they are based on the primitive biological model of nervous systems.

The user of a neural network collates representative data and then runs the learning algorithm that automatically adapts to the data structure. However, the user requires a set of heuristic knowledge about how to select and prepare data, the desired network architecture and to interpret the results.

Currently, there are many successful examples of the application of neural network approach to building intelligent information systems [2, 4].

The ultimate goal of our research is to create neural network systems that allow for the diagnosis and differential diagnosis of lichen planus.

As it generally known, the creation of a neural network system includes the following stages: studying of the problem; problem statement; setting of training data and testing examples; training the neural network; optimal scheme; more experiments; the development and creation of the interface; the connection to the trained neural networks; system test examples not included in training data; a finish system in these examples [3].

As the neural structure was chosen as the Kohonen network, as it is, everyone carries out the classification. The Kohonen network can recognize clusters in data, and to establish intimacy and classes. Thus, the user can improve their understanding of data structures, and then to Refine the neural network model. If these recognized classes, they can be described, after which the network can solve classification problems. The Kohonen network can be used in the classification tasks where the classes are already set, then the advantage is that the network can identify similarities between different classes. Another possible area of application is the detection of new phenomena. The Kohonen network can recognize clusters in the training data and classifies all the data to the different clusters. If the network will meet with the dataset, unlike any of the known samples, it will not be able to classify such a set, and thus reveal its novelty. The network is trained by the Kohonen method of successive approximations. Starting from randomly chosen starting location of the centers, the algorithm progressively improves it in order to capture the clustering of the training data.

The principle of construction of system for differential diagnosis of lichen planus is as follows. Based on the table of differential diagnostics developed by the authors, was composed of simple questions, the answers to which are binary, i.e. "Yes" or "No". In drawing up a "vector of the survey", if the answer should be "Yes", then the vector component is assigned 1 if "No", then 0. This input vectors. Similar is the vector of output values, its components have a binary form.

The most informative characteristics that allow for differential diagnosis of exudative-hyperemic forms of lichen planus are presented in table 1.

Table 1. A list of the most informative signs for differential diagnosis of lichen planus.

Signs of disease	Code sign of the disease
Spontaneous pain	P1
The presence of papules of the oral mucosa	P2
The presence of local irritating factors	P3
The presence of inflammatory infiltration	P4
Localization on the surface of the tongue	P5
Localization on the red border of the lips	P6
Localization in the retromolar region	P7
The patient is a woman over 40	P8
Skin lesions	P9
Reaction of the lymph nodes	P10
The possibility of malignancy	P11
Specific features	P12
A burning sensation in the mouth	P13
The disease is a chronic	P14

The list of diseases for the differential diagnosis of exudative-hyperemic forms of lichen planus are presented in table 2.

The input vectors are eight diseases for the differential diagnosis of exudative-hyperemic forms of lichen planus are given in table 3.

Table 2. The list of diseases for the differential diagnosis of exudative-hyperemic forms of lichen planus.

Disease	Code of disease
Lichen planus, exudative-hyperemic form	X1
Chronic mechanical trauma	X2
Papular syphillis	X3
Leukoplakia, flat shape,	X4
Lupus erythematosus chronic	X5
Allergic stomatitis	X6
Acute hyperplastic candidiasis	X7
Early signs of recurrent aphthous stomatitis	X8

Table 3. A list of the most informative signs for differential diagnosis of lichen planus.

Code sign of the disease	Disease							
	X1	X2	X3	X4	X5	X6	X7	X8
P1	0	0	0	0	0	0	0	1
P2	1	0	1	0	0	0	0	0
P3	0	1	0	1	0	0	0	0
P4	0	1	0	0	1	1	0	1
P5	1	1	1	1	1	1	1	1
P6	1	1	1	1	1	1	1	0
P7	1	1	1	0	1	1	1	0
P8	1	1	1	0	1	1	1	1
P9	1	0	1	0	1	0	0	0
P10	0	0	1	0	0	0	0	0
P11	0	1	0	0	1	0	0	0
P12	1	0	1	0	1	0	1	0
P13	1	0	0	0	1	1	1	0
P14	1	0	1	1	1	0	0	1

The learning algorithm of Kohonen network

The Kohonen network consists of one neurons' layer. The number of inputs of each neuron is *n* –and it is the total number of possible symptoms. The number of neurons *m* is the desired number of classes that need to divide (number of diseases). The significance of each of the inputs into a neuron is characterized by a numeric value called weight.

Training

Step 1: Initialize the network.

The weighted coefficients of the network $w_{ij}, i = \overline{1,n},\ j = \overline{1,m}$ are assigned small random values.

Values are defined α_0 - initial rate of training and

D_0 - the maximum distance between the weight vectors (columns of the matrix W).

Step 2. Presentation the network a new input signal X .

Step 3. Calculate the distance from input X to all neurons of the network:

$$d_j = \sum_{i=1}^{n} (x_i - w_{ij}^N)^2,\ j = \overline{1,m}$$

Step 4. The choice of a neuron $k, 1 \le k \le m$ with the shortest distance d_k.

Step 5. Adjusting the weights of a neuron k and all neurons that are at a distance of no more than

$$w_{ij}^{N+1} = w_{ij}^N + \alpha_N (x_i - w_{ij}^N).$$

Step 6. The decrease in the values of α_N, D_N.

Step 7. Steps 2-6 are repeated until the weight stops changing (or until the total change of all weights will be very small).

After training, the classification is performed by supplying to the input network of the test vector, compute the distance from each neuron and then the neuron with the smallest distance as the indicator of correct classification.

3. Results and Discussion

For training the neural network were taken 180 cases, whose data were taken from the medical records of patients with already confirmed diagnosis. The data of 185 patients treated in the clinic were left to test the system. Table 4 shows examples of correct recognition diagnosis of a number of diseases as a result of the program.

Table 4. The distribution of patients in accordance with the forms of diseases of the oral mucosa and the results of testing

Nosological form of the disease	Number of cases	Number of correctly recognized cases
Ulcerative necrotic stomatitis	78	78 (100%)
Recurrent aphthous stomatitis	101	101 (100%)
Multiforme exudative erythema	33	31 (93,9%)
Lichen planus, erosive-ulcerative form	75	73 (97,3%)
Lichen planus exudative-hyperemic forms	82	78 (96,3)
Leukoplakia erosive forms	37	37 (100%)

For nanosistemy presented certain difficulties, for example, the differential diagnosis between lichen planus and erythema multiforme exudative (2 errors) that occurs frequently in clinical practice when doctors make mistakes that occurs in the 35% of cases.

Comparing the encountered incorrect ("guides diagnoses") of medical institutions in patients with diseases of the oral mucosa and the vermilion border, we can say that adequate "smart diagnosis" is recorded only in 72% of cases. In the remaining patients the diagnosis was incorrect. At the same time, the application developed by authors' algorithm of the neural network allows to obtain a correct diagnosis in 94-97%, which certainly contributes to improve early diagnosis of severe dental diseases.

4. Conclusion

Thus, the developed and implemented algorithm allows effective diagnostics of the forms of lichen planus and its differential diagnosis with other diseases. The system provides the possibility of reducing the amount of input data identifying the most significant indicators. The system is versatile and can be practical used by doctors to diagnose any other diseases by creating appropriate tests.

Program is performing differential diagnosis of lichen planus with the help of Kohonen network that is implemented in the programming system Delphi.

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