Polarization Selection of Birefringence Polycrystalline Networks of Blood Plasma Layers

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***Abstract* – The principles of optical model of human bile polycrystalline structure are described. The results of investigating the interrelation between the values of statistical, correlation and fractal parameters are presented. They characterize the coordinate distributions of mutual polarization degree of the points of laser images of bile smears of cholelithiasis patients in combination with other pathologies. The diagnostic criteria of the cholelithiasis nascency and its severity degree differentiation are determined.**

***Index Terms* – laser polarimetry, mutual polarization, optical diagnostic, plasma, polarization selection, polycrystalline structure**

1. INTRODUCTION

Among the methods of optical diagnostics of human biological tissues the techniques of laser polarimetry diagnostics of their optical anisotropic structure became widely spread [1-9].

The main information for these methods is obtained from coordinate distributions of polarization azimuths $\alpha(x, y)$ and ellipticity $\beta(x, y)$ (polarization maps) with the following correlation (auto- and mutually correlation functions and fractal (fractal dimensions analysis.

As a result, several techniques of early diagnostics and differentiation of pathological changes in biological tissue (BT) structure with their degenerative, dystrophic and oncological changes were developed.

Besides, there is a widely spread group of optically anisotropic biological objects, for which the techniques of laser polarimetry diagnostics are not efficient enough. Optically thin (attenuation coefficient $\tau \leq 0{,}1$) layers of different biological fluids (bile, urine, liquor, synovial fluid, blood plasma, etc.) belong to such objects. Biological fluids are much more accessible for direct laboratory analysis if compared with traumatic techniques of the BT biopsy.

In terms of the above mentioned the task of searching new additional parameters for laser diagnostics of biological fluids' optical anisotropic structure appears to be topical.

This research is focused on the analysis of potentiality of diagnostics and differentiation of cholelithiasis of patients with chronic cholecystitis and 2nd type diabetes by means of new technique of polarization correlometry of human plasma layers laser images [10-22].

2. THE TECHNIQUE OF COORDINATE DISTRIBUTION OF MUTUAL POLARIZATION COMPLEX DEGREE

The technique of determining the parameter of mutual polarization complex degree consists in the following procedure:

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1. By rotating the transmission plane of polarizer within the rotation angle θ 0^0–180^0 the arrays of minimal and maximal intensity levels $I_{\min}\begin{pmatrix} r_{11},..r_{1m} \\ .... \\ r_{n1},..r_{nm} \end{pmatrix}; I_{\max}\begin{pmatrix} r_{11},..r_{1m} \\ .... \\ r_{n1},..r_{nm} \end{pmatrix}$ of human bile layers images for each separate pixel (mn) of CCD-camera were determined , as well as rotation angles $\theta\left(\begin{pmatrix} r_{11},..r_{1m} \\ .... \\ r_{n1},..r_{nm} \end{pmatrix} I\begin{pmatrix} r_{11},..r_{1m} \\ .... \\ r_{n1},..r_{nm} \end{pmatrix} \equiv \min\right)$ corresponding to them.

2. The coordinate distributions (polarization maps) of polarization states in the plane of human bile samples images were calculated by such relations

$$\alpha\begin{pmatrix} r_{11},...r_{1m} \\ .... \\ r_{n1},...r_{nm} \end{pmatrix} = \theta(I(r_i) \equiv \min) - \frac{\pi}{2};$$
$$\beta\begin{pmatrix} r_{11},...r_{1m} \\ .... \\ r_{n1},...r_{nm} \end{pmatrix} = arctg\frac{I(r_i)_{\min}}{I(r_i)_{\max}}. \quad (1)$$

3. The value of complex degree of mutual polarization $V(r; r + \Delta r)$ of human bile samples' laser images was calculated by the following relation

$$V(r;r+\Delta r)=\frac{2\left\{I_0 I_{90}\cos\left[\arcsin\left(\cos 2\alpha / tg 2\beta\right)\right]\right\}(r)\times \left\{I_0 I_{90}\cos\left[\arcsin\left(\cos 2\alpha / tg 2\beta\right)\right]\right\}(r+\Delta r)}{\left(I_0^2(r)+I_{90}^2(r)\right)\left(I_0^2(r+\Delta r)+I_{90}^2(r+\Delta r)\right)} \quad (2)$$

3. EXPERIMENTAL RESULTS AND DISCUSSION

Laser images of three groups of blood plasma samples of the patients of different pathological state:

- healthy patients – group 1 (11 patients);
- patients with benign breast changes – group 2 (10 patients);
- patients with malignancy of the breast – group 3 (12 patients).

The coordinate distribution and histogram of random values of $V(x,y)$ parameter of polarizationally-inhomogeneous laser image of blood plasma layer laser image of a healthy patient are presented in Fig. 1.

It can be seen from the obtained data that the laser image of a healthy patient's bile layer is characterized with a high homogeneity of polarization parameters – the number of values $V(x,y)=1$ is by three orders higher than the other, non-zero values of mutual polarization degree.

In other words, in biochemical structure of this bile layer the optically isotropic component prevails.

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The following parameters of values distribution of liquid-crystalline sampling ($V(x,y)=0,5$) of mutual polarization degree of laser images of human blood plasma layers belong to the basic criteria of diagnosing cholelithiasis latent course and differentiating its pathology types - statistical moments ($M_{i=1;2;3;4}(V)$) of distribution of mutual polarization degree values $V(x,y)=0,5$.

The ensemble of data about the values of diagnostic parameters $M_{k=1;2;3;4}(V=0,5)$ is presented in Table 1.

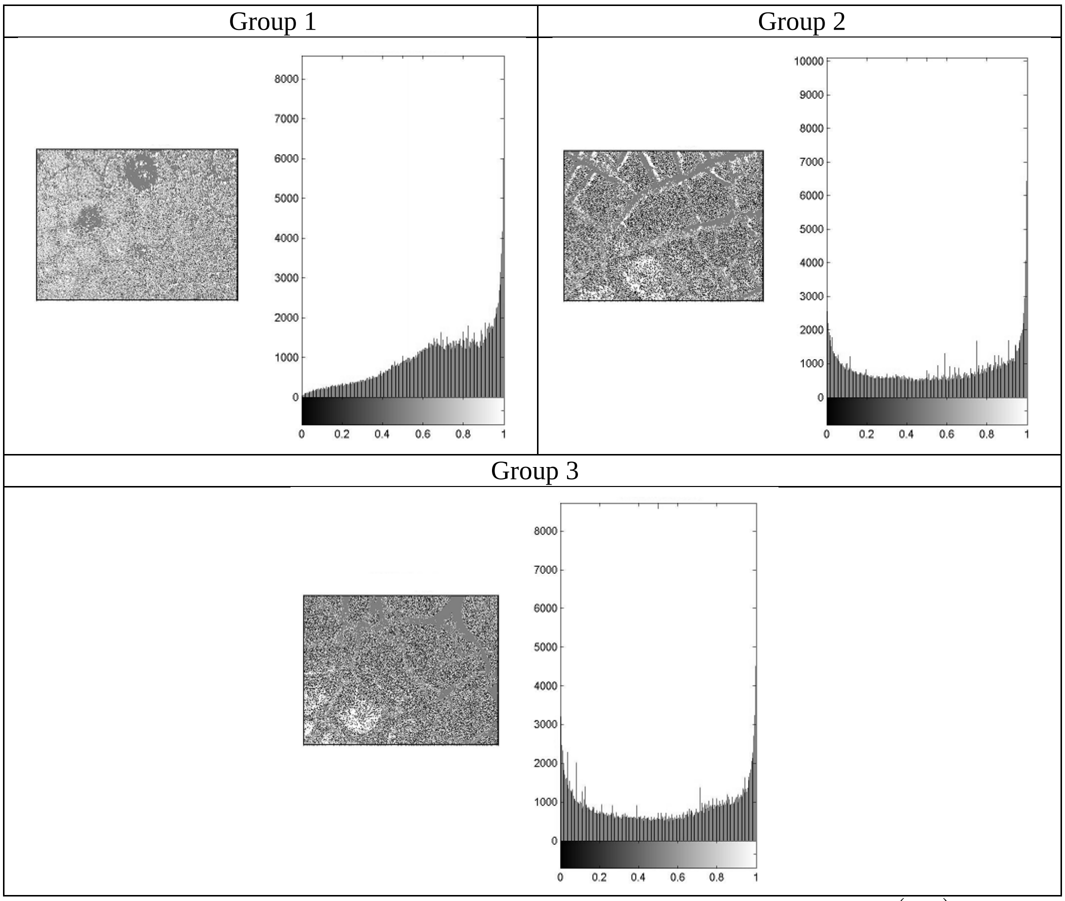

Fig. 1. Coordinate distribution (a) and histogram of values (a) of mutual polarization $V(x,y)$ degree of blood plasma layer (groups 1-3).

TABLE 1. STATISTICAL MOMENTS OF THE 1ST-4TH ORDERS OF DISTRIBUTIONS $V(x,y)=0{,}5$ OF BILE LAYERS OF ALL GROUPS OF PATIENTS

Parameters	Group 1	Group 2	Group 3
$M_1(V=0{,}5)$	$0{,}09 \pm 0{,}008$	$0{,}21 \pm 0{,}027$	$0{,}32 \pm 0{,}019$
$M_2(W=0{,}5)$	$0{,}26 \pm 0{,}031$	$0{,}13 \pm 0{,}023$	$0{,}12 \pm 0{,}019$
$M_3(W=0{,}5)$	$0{,}11 \pm 0{,}021$	$1{,}28 \pm 0{,}41$	$4{,}26 \pm 0{,}58$
$M_4(W=0{,}5)$	$0{,}09 \pm 0{,}009$	$2{,}12 \pm 0{,}52$	$5{,}29 \pm 0{,}0096$

The obtained data about the coordinate distributions of mutual polarization degree of laser images of blood plasma of all groups of healthy and sick patients prove that the statistical analysis of dependencies of the number of values of $V(x,y)=0{,}5$ sampling (liquid-crystalline phase) enable to reliably diagnose.

The difference between statistical moments $M_k(W)$ of laser images of test group patients' blood plasma (group 1) and the patients with various pathologies (groups 2 and 3) – mean (increasing by 2.7 – 3.5 times); dispersion (decreasing by 2.5 – 3.3 times); asymmetry (increasing by 3.3 – 5.4 times) and excess (increasing by 4.5 – 6.1 times) – are determined.

3. CONCLUSIONS

1. A new technique of estimating the structure of laser images based on measuring coordinate distributions of mutual polarization degree is suggested that characterizes the homogeneity of optically isotropic and optically anisotropic components in biochemical composition of blood plasma.

2. The statistical (mean, dispersion, asymmetry and excess), correlation (correlation area of distribution of mutual polarization degree values) and fractal (dispersion of extremes of log-log dependencies of power spectra of mutual polarization degree values distribution) criteria of polarization-correlation diagnostics of cholelithiasis latent course and its stages differentiation on the background of chronic cholecystitis, diabetes and complex pathology are determined and substantiated.

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