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Differential diagnosis in prostate tumors by the 3D Stokes-correlometry of layer-by-layer polarization-inhomogeneous images of polycrystalline blood films

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Introduction & Objectives: Prostate cancer (PC) is the second most commonly diagnosed cancer in males, only behind skin cancer. Prostate cancer tends to progress slowly and less aggressively than many other types of cancer. If detect prostate cancer in the early stages and get the necessary treatment, there's a very high chance of survival (in the USA, the 5-year survival rate with prostate cancer is close to 98 percent in the early stages).

Materials & Methods: Study focuses on the development and experimental testing of a new method of 3D Stokes-correlometry mapping of polarization-inhomogeneous fields of biological optically anisotropic layers. Digital holographic reconstruction of 3D layered distributions of the module and phase of "two-point" parameters of the Stokes vector is used for express diagnosis and differentiation of diffuse samples of polycrystalline blood films taken from patients with PC. For the purpose of express (up to 7 min) determination of the type of tumor three representative groups were formed: Group 1 - polycrystalline film samples of blood and its plasma taken from patients with well-differentiated Adenoca (3+3 on Gl scale - ISUP grade 1); Gr 2 - film samples of blood and its plasma taken from pts with moderately differentiated Adenoca (3+4; 4+3 on Gleason's Pattern scale - ISUP gr 2-3), Gr 3 consisted of polycrystalline Adenoaca blood plasma samples poorly differentiated (4+4;5+3;3+5 on Gl – ISUP grade 4).

Results: Adenocarcinoma polycrystalline blood film samples were diagnosed with excellent balanced accuracy $93.1\% \le Ac_{12;13}\ (\imath S_{4}\imath(\theta^*)) \le 95.8\%$ and $90.3\% \le Ac_{12;13}\ (Arg S_{4}(\theta^*)) \le 93.1\%$. Differentiation of samples of polycrystalline blood films taken from patients with malignant tumors with different degrees of differentiation with high accuracy $Ac_{23}\ (\imath S_{4}\imath(\theta^*))=90.3\%$ and $Ac_{23}\ (Arg S_{4}(\theta^*))=88.9\%$ was implemented (ISUP gr 2-3 and ISUP grade 4).

Table 1 Optical parameters of polycrystalline blood films taken from patients with prostate tumors

Parameter	Group 1	Group 2	Group 3
Attenuation (extinction) coefficient τ, cm^{-1}	0.61±0.041	0.63±0.037	0.62±0.039
Depolarization degree Λ, %	38±0.78	42±0.81	40±0.73

Table 2 Intergroup differences in the magnitude of the central statistical moments of the 3th - 4th orders $\Delta\overline{Z}_{i=3;4}$.

w	$\lvert S_4\rvert(\theta^*, r_1, r_2)$			$Arg S_4(\theta^*, r_1, r_2)$		
Groups	**Group 1-Group 2**	**Group 1-Group 3**	**Group 2-Group 3**	**Group1-Group 2**	**Group 1-Group3**	**Group 2-Group 3**
ΔZ_3	0.34± 0,015	0.51± 0.024	0.25± 0.013	0.29± 0,014	0.34± 0.023	0.21± 0.012
ΔZ_4	0.44± 0.021	0.57± 0.028	0.33± 0.014	0.38± 0.019	0.45± 0.022	0.26± 0.012

Table 3 Selectivity, specificity, and balanced accuracy of the diagnostic power of the polarization-correlation maps w blood layers in optimal phase sections corresponding to $\theta^* = 0.35 rad$

w	$\lvert S_4\rvert(\theta^*, r_1, r_2)$			$Arg S_4(\theta^*, r_1, r_2)$		
Groups	**Group 1-Group 2**	**Group 1-Group 3**	**Group 2-Group 3**	**Group1-Group 2**	**Group 1-Group3**	**Group 2-Group 3**
Se (%)	94.4	97.2	91.7	91.7	94.4	88.9
Sp (%)	91.7	94.4	88.9	88.9	91.7	88.9

Conclusions: Describes the results of studying the relationship between 3D distributions of the optical anisotropy parameters of polycrystalline blood film networks and layer-by-layer phase maps of the module and phase of the parameters of the "two-point" Stokes vector of a microscopic image. Physically substantiated and experimentally determined the effectiveness of the method of 3D Stokes-correlometric mapping of blood film preparations in differentiating malignant conditions of prostate tissue with varying severity.