The investigation of thrombus formation process in blood plasma by correlation-optical technique

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Abstract

The method of laser express diagnostics of thrombus formation process in a blood plasma is presented. This method is based on analysis of image correlation of blood plasma during thrombus formation process. The technique of experimental researches of scattering laser radiation by blood plasma is shown. It is established that the dynamic of intensity fluctuations of scattered by blood plasma radiation decreases under the influence of thrombin that causes increasing correlation coefficient and gives the possibility to estimate continuance of thrombus formation process.

Keywords: Thrombus formation process, blood plasma, correlation coefficient

1. Introduction

Thrombus formation process (coagulation hemostasis) is complex and extremely important in the functioning of living organisms including man. In modern clinical and scientific researches the optical methods for investigation of system hemostasis components gain wide application [1-3]. These methods register changes of optical properties of the incubatory environment during grume formation. The fibrinogen is the source of fibrin in plasma as well as in whole blood. Investigation of the coagulation process and fibrinolysis in plasma and whole blood is of high interest for clinical practice as it gives the possibility of determination of fibrinogen concentration of under the conditions as much as possible approached to the physiology.

At present, the concentration of fibrinogen is determined by coagulation technique (by the time of grume formation in dissolved nonthrombocyte plasma after thrombin addition). Determination of thrombin time allows estimating the final stage of fibrillation of a blood (a fibrinogen transformation into a fibrin) [3].

During thrombus formation process few tens of biochemical reactions cause the formation of fibrin - the basis of hemostatic thrombus. Viscosity of the clot increases repeatedly during the process thrombus formation. Increasing of clot viscosity causes decreasing of dynamic parameters of radiation field scattered by blood plasma, which can be evaluated experimentally and qualitatively by the correlation of the radiation field intensity distribution for close points of time [4-6].

Thus analysis of correlation of scattered by blood plasma radiation field gives the chance to solve partially a return problem that is important in cases of the dynamical medium connected with diagnostics in the course of structural transformations. The aim of the investigation is testing of method of thrombus formation time determining by analyzing the correlation of intensity of the radiation field scattered by blood plasma in close points of time.

We use correlation coefficient to estimate correlation of scattered radiation field [7]. The correlation coefficient for images $A$ and $B$ can be calculated by the following equation:
where m, n – size of image in pixels, $\bar{A}$, $\bar{B}$ – average intensity values of images.

If correlation coefficient is close to zero ($r \approx 0$) then correlation between images is absent and if correlation coefficient is close to one ($r \approx 1$) then images have correlation.

2. Methodology

We investigated the correlation of images of blood plasma during thrombus formation process for close points of time. For experimental researches blood group O (I) was used. In order to avoid premature fibrillation preservative have preliminary been added to the sample of blood. The measurement of fluctuation intensity of scattered laser radiation by blood plasma was carried out as follows: a cell with the sample (whole blood 0,2 ml) was placed in accordance with the experiment scheme (fig. 1), and thrombin solution (0,2 ml) was added. Thrombin causes fibrinogen transformation into fibrin which causes fibrillation of blood. It is obvious, that such structural transformations influenced dynamic of image of blood plasma. The recording of images was performed with the frequency of 4 Hz.

The frequency of recording was chosen experimentally. Increasing frequency of recording from one side causes increasing number of experimental points and from other side causes increasing correlation of neighboring frames that complicates determining time of thrombus formation.

3. Results and discussion

As a result of the experiment, the intensity distribution of scattered laser radiation by blood plasma during thrombus formation process has been found (Fig. 2). For example, in Fig. 2 fragments of scattered radiation field are presented: a – 5 sec. after start of recording, b – 10 sec. after start of recording, c – 15 after start of recording.
Correlation coefficients were calculated for neighboring frames of object obtained with frequency 4 Hz. In Fig. 3 time dependence of correlation coefficient of images of blood plasma is shown.

Addition of thrombin into blood plasma (on the 3rd second after the data recording beginning (Fig. 3)) has led to fast decreasing of correlation neighboring images of blood plasma as a result of turbulent mixing of thrombin with blood plasma. As a result of reaction of thrombin with fibrinogen threads of fibrin are formed. It causes the growth of blood viscosity and reduction of dynamic parameters of blood plasma. The basic parameter of estimation of time dependence correlation coefficient during thrombus formation process is: \( \Delta t_1 \) – time of formation of a blood clot - a time difference between the position of a saturation of the dependence of the correlation coefficient and beginning time of thrombus formation process.

Fig. 3. Time dependence of correlation coefficient images of blood plasma, \( \Delta t_1 = 12,4 \) sec.
To estimate reliability of the received results we measured time thrombus formation for samples of plasma of the same blood by turbidimetric method [8, 9].

4. Conclusion
On analyzing the time dependence of the correlation coefficient (Fig. 3) it is possible to conclude, that during the action of thrombin the correlation of neighboring images of blood plasma increases, that gives the possibility to estimate the time of thrombus formation ($\Delta t_1 = 12.4$ sec.), which correlates with the time of thrombus formation defined by turbidimetric method ($\Delta t_1 = 12$ sec.).

Hence, the offered method gives the possibility to investigate thrombus formation process and to estimate the time of thrombus formation. This method can be used as a base of new portative device for measuring time of thrombus formation in real time.

References