COAGULATION SCREENING BASED ON ULTRASOUND PHASE MONITORING

Ushakova A.A.

Belorusian state university of informatics and radioelectronics
P. Browki Str., 6, BSUIR, ETE dept., 220013, Minsk, Belarus
E-mail: ushakova@bsuir.by

Abstract. Many clinical conditions can lead to excessive bleeding. Clotting is what prevents excessive bleeding when the blood vessel is damaged and at the same time it allows blood to move inside vessels without developing clots. Coagulation tests measure blood's ability to clot, as well as how long it takes to clot. Tests may be conducted to identify specific coagulation factor deficiencies and help doctor to put on appropriate treatments. Coagulation tests are also useful in monitoring people who take medications that affect clotting ability.

Several techniques, including clot-based tests, chromogenic or color assays, direct chemical measurements are used for coagulation testing. Laboratory-based coagulation tests are most commonly used. The principal coagulation-screening tests are the activated partial thromboplastin time (APTT) and the protrombin time (PT). The APTT is a test of the so-called intrinsic and common pathways of coagulation in recalcified citrated plasma. It reflects the activities of most of the coagulation factors, including factor XII and other "contact factors". The APTT is variably sensitive to the presence of specific and nonspecific inhibitors of the intrinsic and common coagulation pathways, including lupus anticoagulants or antiphospholipid antibodies[1]. The PT assesses the so-called extrinsic and common pathways. Tissue-factor thromboplastin and calcium are added to citrated plasma. Prothrombin time is an important test because it checks if five different blood clotting factors (factors I, II, V, VII, and X) are present.

Coagulation-screening tests are performed using special devices for blood coagulation time measuring called coagulometers. Coagulometer measures time interval between adding the reagent initiating clotting reaction and fibrin clot formation. Modern coagulometers are based on the following methods of fibrin clot determination:

- electromechanical (as a clotting thread is formed it causes the stainless steel ball movement, which is detected by the sensor);
- optical (detection of clot formation measured by a change in the amount of light passed through a test solution by photodetector);
- electrochemical (blood mixes with reagents that start the clotting reaction and as the blood clots device detects a change in the sample impedance).

All of the available tests have their limitations. Any new method enhances the researchers' ability and creates opportunities for new background and new examination devices. That's why it was suggested to use ultrasound for detection of clot formation.

In this method [2] detection of clot formation is based on the monitoring of variations in ultrasound signal amplitude. But the ultrasound signal amplitude differs a lot according to the state of acoustic contact between ultrasonic sensor and measuring cuvette surface. It is difficult to achieve good contact between the cuvette and the sensor because of the small size of contact surface. Bad contact reduces the signal amplitude and causes measuring uncertainty.

Thereby it is better to use the phase as an informative parameter of the ultrasound signal. Phase shifting is independent of the contact surface state and measuring value will give better accuracy.

The key point of new method is that the cuvette with the test solution places between two sensors and ultrasonic irradiation passes through it (Figure 1). The first sensor generates the ultrasound waves. When soluble fibrinogen begins to polymerize into a fibrin clot, fibrin strands formation causes changing in ultrasonic waves' path length and their velocity. The second sensor receives an ultrasound signal after cuvette and converts it back to electrical signal.

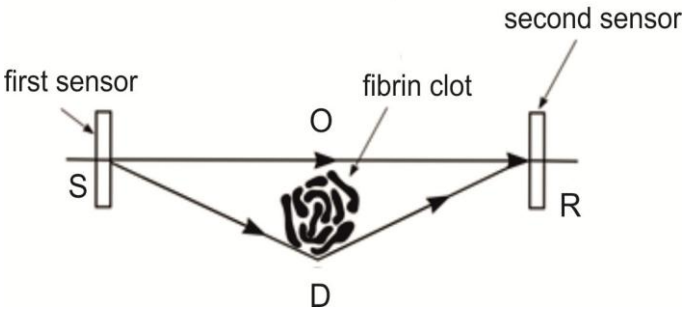

Figure 1 – Fibrin Clot Formation

The pathway SDR of the ultrasound beam longer that the pathway SOR. The equation 1 shows that the phase value is directly-proportional to the distance SR between the sensors.

$$\varphi = \frac{2\pi f d}{c}, \quad (1)$$

where, f – ultrasound frequency, d – distance between the sensors, c – ultrasound velocity.

So this change in the ultrasonic waves' path length causes the phase value change and the shifting between the signals before the cuvette and after it appears. It is possible to use the oscilloscope to observe the phase shifting of an electrical signal over time (Figure 2).

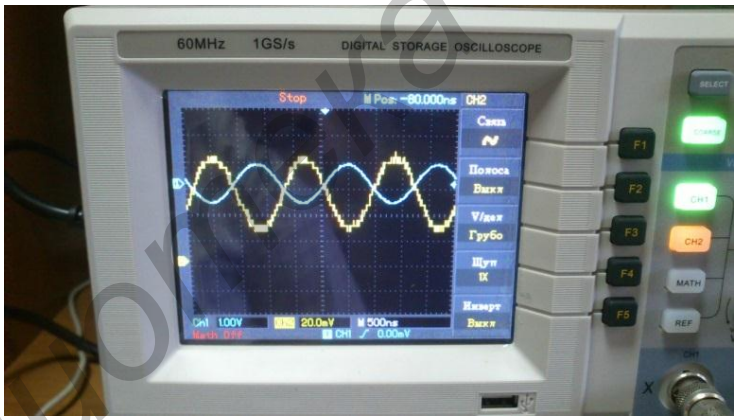

Figure 2 – Phase Shifting on the Oscilloscope

If phase shifting is measured during the coagulation process from the clotting reaction starting point to the end of clot formation a graph phase profile can be drawn (phase shifting as a function of time). Phase profiles from both APTT and PT assays may have diagnostic utility. The possible utility of clotting tests phase profile waveform analysis is to predict the presence of heparin or factor deficiencies.

Conclusions. All of the current screening tests of haemostasis and blood coagulation have limitations and it is clear that in the diagnostic of bleeding disorders there is a need in new methods, new examination devices. The use of ultrasound in coagulation screening tests could provide a more accurate measurement, improve outcomes and reduce measuring time.

References

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2. **Bondarik V.M.,** Degtyarev U.G., Kamlach P.V. // Izobretatel. 2012.№10(154). S.36-39.