mindray

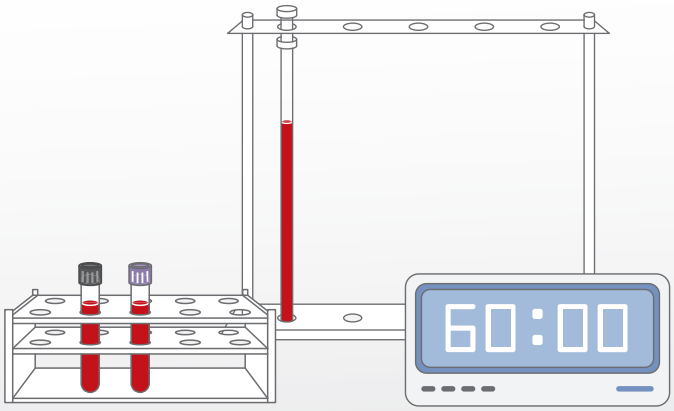
BC-700 Series

Auto Hematology Analyzer with ESR

Easy-W ESR Solution

Traditional Westergren method

Erythrocyte sedimentation rate (ESR), a traditional and widely used indicator, may elevate in condition of inflammatory diseases, tissue damage, autoimmune diseases, malignancies, hyperglobulinemia and hypercholesterolemia. Westergren method is the traditional method for ESR measurement, and also the reference method recommended by International Council for Standardization Hematology (ICSH).



Although Westergren method has been used as the reference method, customers have always been troubled by its long testing time, complex procedures, large number of consumables, blood exposure and other deficiencies. Semi-automatic ESR analyzers, most of which adopt the modified Westergren method, shorten the measurement time to half an hour and use the 0.5h sedimentation distance to predict the 1h ESR value, which still take a long time and usually require the application of a special blood sedimentation tube for additional blood drawing. The rapid method based on erythrocyte aggregation degree information is currently the fastest ESR measurement method. It solves the problem of long testing time but suffers from the poor accuracy of results. In order to improve the work efficiency and result accuracy at the same time, Mindray provides Easy-W ESR solution in BC-700 series auto hematology analyzer for customers.

Three stages of erythrocyte sedimentation process

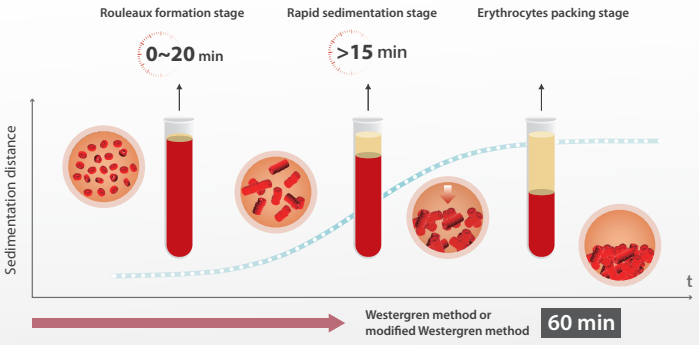


Figure 1 Three stages of erythrocytes sedimentation

The erythrocyte sedimentation process can be divided into three stages, i.e. rouleaux formation stage, rapid sedimentation stage and packing stage, according to which, the erythrocyte sedimentation occurs after erythrocyte aggregation in rouleaux formation stage which plays an important role in determining the final ESR result. A large number of studies have shown that erythrocytes in rapid sedimentation stage fall down with a constant speed which in turns depends on the erythrocytes aggregation state in the rouleaux formation stage [1].

Thus there is a great possibility that the whole dynamic ESR curve can be simulated to predict the 1 hour ESR value through the high frequency signal monitoring of erythrocytes aggregation state changes in few seconds in the rouleaux formation stage.

BC-700 series Easy-W ESR solution principle

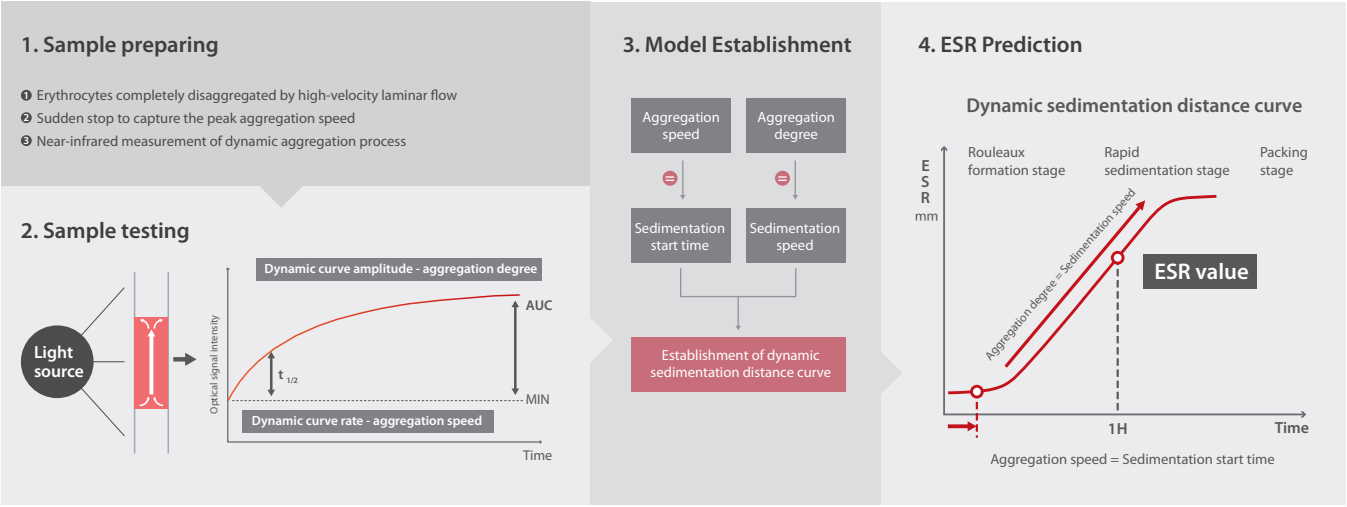


Figure 2 Principle of Mindray Easy-W ESR solution

Mindray BC-700 series Easy-W ESR solution adopts near-infrared photometry for precise measurement of the erythrocyte aggregation state in rouleaux formation stage, and the information of both erythrocyte aggregation speed and degree are obtained, based on which the whole ESR curve model is simulated. Different from the rapid method which is based only on aggregation degree, Easy-W ESR solution combines both the speed and degree information leading to a more accurate ESR result which is highly correlated with Westergren method. Besides, it solves the problem of poor accuracy of the current rapid method and realizes the rapid and precise ESR measurement sharing one tube of blood with CBC test in only 72 seconds.

Key factors of Easy-W ESR solution

1. Erythrocyte aggregation speed

Erythrocyte sedimentation begins after erythrocyte aggregation in rouleaux formation stage. The aggregation speed of erythrocyte aggregates determines the time required for erythrocyte aggregation, which further determines the time when erythrocyte rapid sedimentation begins [2]. The faster the erythrocytes aggregate, the shorter the time it takes to gather into aggregates, the earlier the erythrocytes start the rapid sedimentation stage, and the higher the one-hour ESR value is eventually.

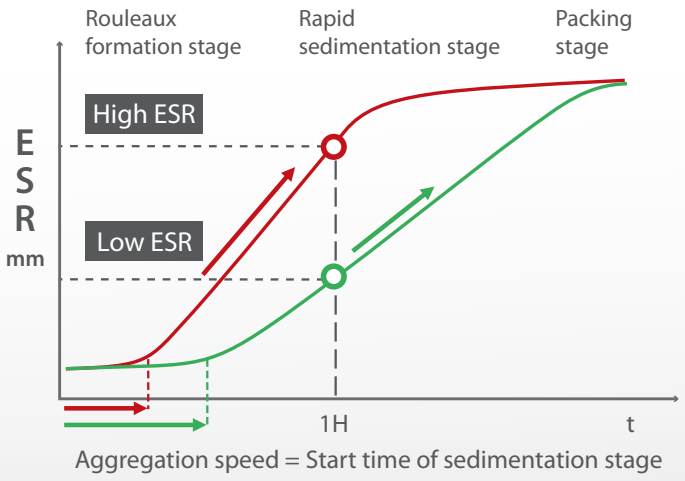


Figure 3 Influence of erythrocyte aggregation degree and speed on dynamic sedimentation distance curve

2. Erythrocyte aggregation degree

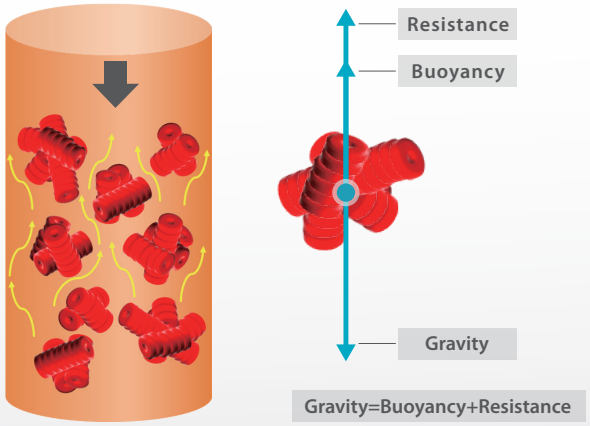


Figure 4 Schematic of rapid sedimentation of erythrocyte aggregates

The sedimentation speed of rapid sedimentation stage is determined by the erythrocyte aggregation degree in rouleaux formation stage. The erythrocyte aggregates are under force balance during rapid sedimentation at a constant speed, therefore, the speed mainly depends on the size of aggregates. Erythrocyte aggregates is formed by the aggregation of erythrocytes, and their aggregation degree determines the size of the aggregates and therefore the sedimentation speed at rapid sedimentation stage.

From the above analysis, it can be known that the speed and degree of erythrocyte aggregation determine the start time and speed of rapid sedimentation stage respectively, and they are the key factors to determine the final ESR value.

How to achieve a reliable result in Easy-W ESR

In order to achieve rapid and accurate ESR measurement, Mindray Easy-W ESR solution obtains the degree and speed of erythrocyte aggregation by measuring the erythrocyte aggregation process in a short period of time, and predicts the 1h ESR value according to the established erythrocyte aggregation and sedimentation model. Erythrocyte aggregation is a dynamic and rapid process. To accurately obtain the aggregation parameters, especially the aggregation speed, it is necessary to measure the complete aggregation process starting from monodisperse erythrocytes state.

1. Complete disaggregation of erythrocytes by high-velocity laminar flow

Erythrocytes aggregation is a dynamic and reversible process. In order to accurately measure the aggregation degree and speed of erythrocytes, erythrocytes must be totally disaggregated first to allow them reaggregate from monodisperse state. In the presence of shear force, the erythrocyte aggregates can be disaggregated into smaller ones, and finally into monodisperse state if the shear force is strong enough [3]. The maximum shear rate in Easy-W ESR measurement tube is approximately 1050 s^{-1}, which will ensure the complete disaggregation of erythrocytes.

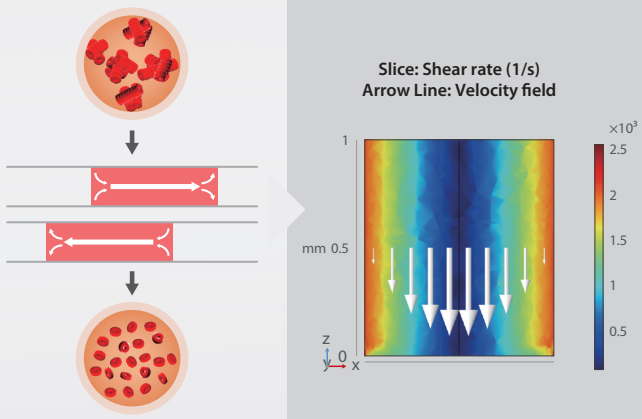


Figure 5 Shear rate in high-velocity laminar flow

2. Sudden stop to capture the peak aggregation speed

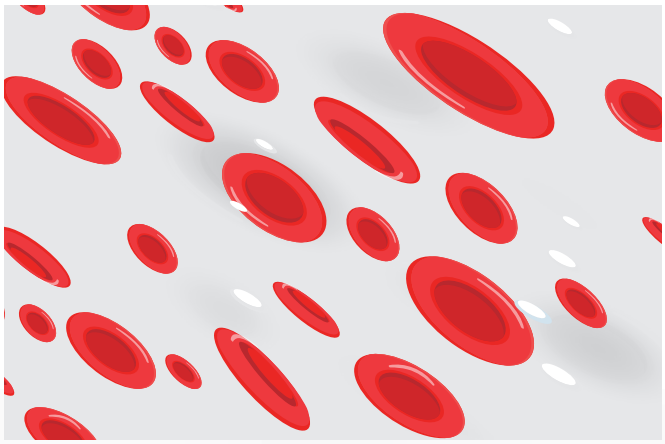


Figure 6 (left) RBCs under high-speed shear force

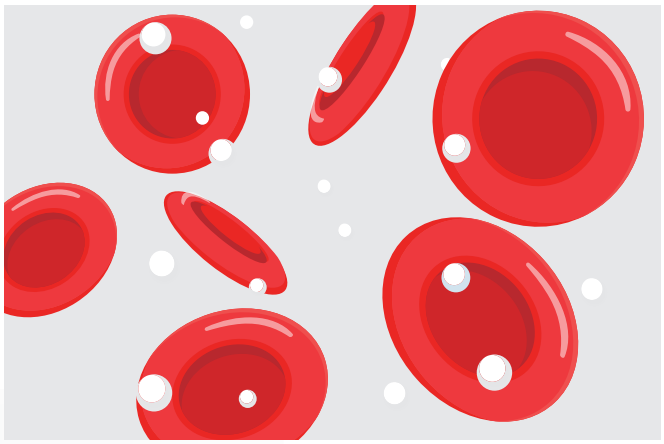


Figure 6 (right) RBCs under static condition

Erythrocytes are disaggregated under shear force with morphology deformation and start to reaggregate with morphology recovery the instant the shear force disappears [4]. The aggregation speed peaks in the beginning period, therefore it is crucial to measure the speed from this period. In order to avoid residual shear force hindering erythrocytes reaggregation and to accurately capture the peak aggregation speed from the monodisperse state, shear action must be completely removed before the deformation recovery to ensure the erythrocytes start reaggregation without the interference of shear force. Special-designed tubes with fast response time are applied in Easy-W ESR solution which ensures the complete removal of residual shear force so that accurate measurement of the peak aggregation speed could be guaranteed.

3. Near-infrared measurement of dynamic aggregation process

The erythrocyte aggregation process is measured in real time by near-infrared photometry in Easy-W ESR solution. According to the erythrocyte scattering model, the monodisperse erythrocyte displays the strongest scattering effect on the incident light and the weakest transmitted light intensity. As the aggregation degree of erythrocytes increases, the scattering effect decreases and the transmitted light intensity gradually increases. Therefore, measuring the transmitted light intensity change of blood samples can accurately reflect the aggregation process of erythrocytes [5].

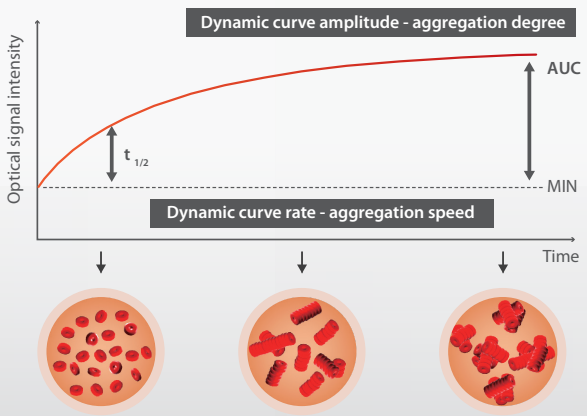


Figure 7 Changes in transmitted light intensity during erythrocyte aggregation

4. Elimination of temperature interference by constant temperature module

The erythrocyte aggregation process is sensitive to ambient temperature. The higher the temperature is, the faster erythrocytes aggregate and the higher the aggregation degree is [6].

The measurement module of Easy-W ESR adopts 37°C constant temperature design to simulate human body temperature, which effectively avoids the influence of environmental temperature changes on erythrocytes aggregation and ensures the stability of measurement results.

Figure 8 Constant temperature module for Easy-W ESR measurement.

Clinical performance

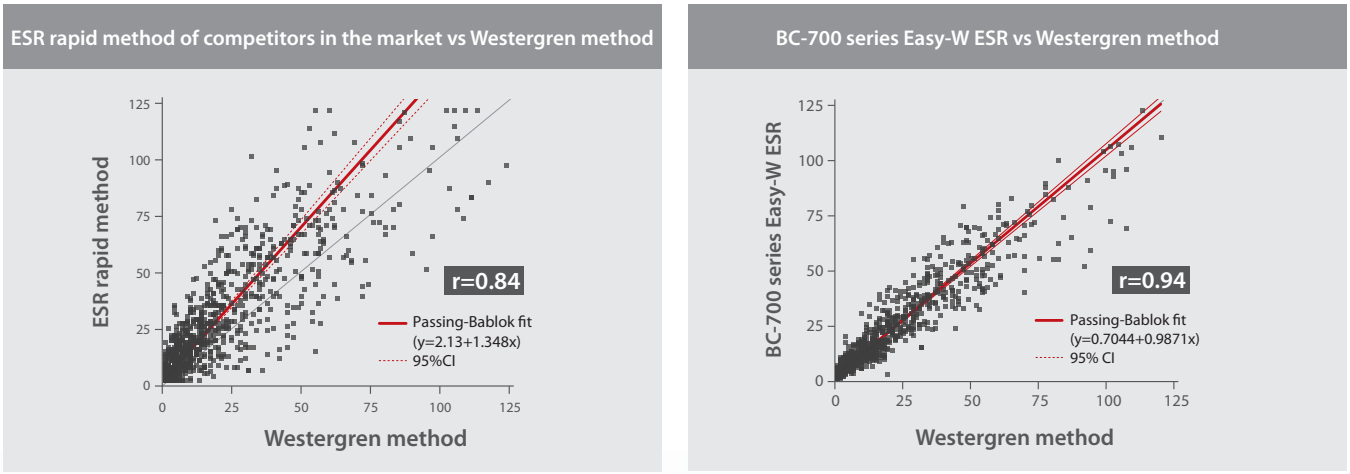


Figure 9 Comparison between Westergren method and ESR rapid method and BC-700 series Easy-W ESR, respectively.

According the performance data, the correlation coefficient between BC-700 series Easy-W ESR method and Westergren method is 0.94, which is significantly better than the results of ESR rapid method of competitors in the market

Reference:

[1] Fabry, T. L., Mechanism of erythrocyte aggregation and sedimentation. Blood, 1987. 70(5): 1572-1576.
[2] Baskurt, O., Red blood cell aggregation. CRC Press, 2012.
[3] Shin, S., et al, A transient, microfluidic approach to the investigation of erythrocyte aggregation: The threshold shear-stress for erythrocyte disaggregation. Clinical Hemorheology and Microcirculation, 2009. 42: 117–125.
[4] Schmid-SchSnbein, H., et al., Microrheology and light transmission of blood iii. The velocity of red cell aggregate formation. Pflfigers Arch, 1975. 354: 299-317.
[5] Shvartsman, L. D. & Fine, I., Optical transmission of blood: effect of erythrocyte aggregation. IEEE TRANSACTIONS ON BIOMEDICAL ENGINEERING, 2003. 50(8): 1026-1033.
[6] Manley, R. W., The effect of room temperature on erythrocyte sedimentation rate and its correction. J. clin. Path., 1957. 10: 354-356.

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