University of Diyala/ College of Medicine
Department of Physiology
Physiology Lab

Erythrocyte Sedimentation Rate (ESR)

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October 27th 2019

Outlines

- Objectives of the Experiment
- Introduction, Mechanism, and Principle
- Methods of Determination ESR
- Procedure
- Clinical Significance

Objectives

1. To know how to measure Erythrocyte Sedimentation Rate (ESR).
2. To get an idea about the mechanism and principle of ESR.
3. To recognize the clinical value of ESR.

Introduction

- ***The Erythrocyte Sedimentation Rate (ESR)*** is a common hematological test for nonspecific detection of inflammation that may be caused by infection, some cancers and certain autoimmune diseases.
- ***ESR*** can be defined as a measurement of the rate at which the RBCs (erythrocytes) settle from the plasma in anticoagulated blood.
- It measures the amount of ***inflammation*** in your body.
- It is ***non specific test*** ,meaning that it does not tell your doctor exactly where the inflammation is occurring in the body, or what is causing it, and also because it can be affected by other conditions besides inflammation. Thus, ***ESR*** is typically used in conjunction with some other tests.
- It is used an initial screening tool and also as a follow up test to monitor therapy and progression or remission of disease.
- ***ESR*** is helpful in diagnosis of two specific inflammatory diseases : ***temporal arteritis*** and ***polymyalgia rheumatica***.
- The ***ESR*** test is easy to perform and inexpensive.
- **In general , normal range**:

  0-10 mm/hr in adult men

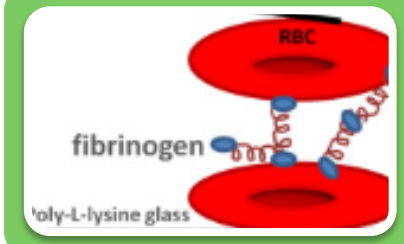
  0-15 mm/hr in adult women

Introduction

- **However, new studies have reported the following as normal ESR test results:**

  - Women under age 50 should have an ESR under 20 mm/hr.
  - Men under age 50 should have an ESR under 15 mm/hr.
  - Women over age 50 should have an ESR under 30 mm/hr
  - Men over age 50 should have an ESR under 20 mm/hr.
  - Newborns should have an ESR under 2 mm/hr.

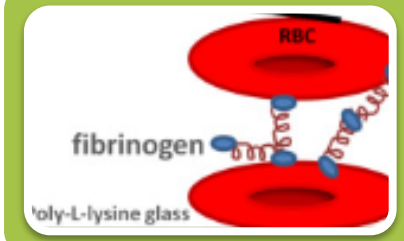
Introduction



ESR is determined by the interaction between factors that promote (fibrinogen) and factors that resist (negative charge of RBC) sedimentation.

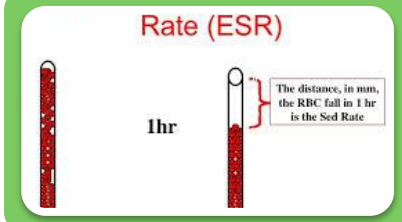
Normally, RBCs settle down slowly as they do not form rouleaux. Instead, they gently repel each other due to the negative charge on their surface.

Rouleaux are stacks of many RBCs that become heavier and settle down faster.



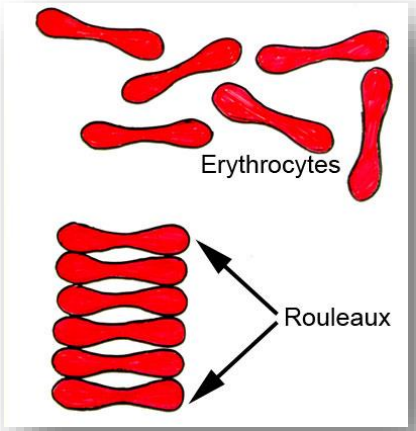
Plasma proteins, especially fibrinogen, adhere to the red cell membranes and neutralize the surface negative charges, promoting cell adherence and rouleaux formation.

Mechanism



ESR is directly proportional to the weight of the cell aggregates and inversely proportional to the surface area.

- ***To summarize:*** RBCs sediment by rouleaux formation, the RBCs aggregate one on the top of each other which will increase the speed of sedimentation. When an inflammatory process is taking place in the body, the high proportion of fibrinogen in the blood causes RBCs to stick on each other. The RBCs form stacks called “rouleaux” which settle faster. rouleaux formation can also occur in association with some lymphoproliferative disorders in which one or more immunoglobulins are secreted in high mounts.



Rouleaux Formation and how it looks like under microscope

Some Important Notes

ESR and CRP (C-reactive protein) are both **markers of inflammation**. Generally, ESR does not change as rapidly as CRP either at the start of the inflammation or as it goes away. CRP is not affected by many factors as ESR does making it a better marker of inflammation. However, because ESR is easily performed test, many doctors still use it as an initial test when they suspect that the patient may have inflammation.

If ***ESR got elevated***, it is typically a result of ***globulin or fibrinogen***. The doctor may then order a fibrinogen level (a clotting protein that is another marker of inflammation) and serum protein electrophoresis to determine which one of them (or both) causing the elevated ESR.

In a pediatric setting, ESR test is used in diagnosis and monitoring of the children with rheumatoid arthritis or Kawasaki's disease.

Some medications such as dextran, methyldopa, oral contraceptives, penicillamine procainamide, and vitamin A can cause an increase in ESR On another hand, aspirin, cortisone, and quinine may decrease it.

Principle of ESR

- When anticoagulated blood is allowed to stand in a narrow vertical glass tube, undisturbed for a period of time, the RBCs – under the influence of gravity- settle out from the plasma. The rate at which they settle is measured as the number of millimeters of clear plasma present at the top of the column after one hour(mm/hr). This mechanism involves ***three stages:***

Stage of aggregation

It is the stage of rouleaux formation/aggregation. It occurs in the first 10-15 min.

Stage of sedimentation

It is the stage of actual RBCs sedimentation, it occurs at constant rate. This occurs in 30-40 minutes out of 1hr.

Stage of packing

This is the final stage and is also known as stationary phase. In this stage, there is a slower rate of falling during which packing of sedimenting RBCs in column occurs due to overcrowding. It occurs in final 10 minutes in 1 hour.

Methods Of ESR Determenation

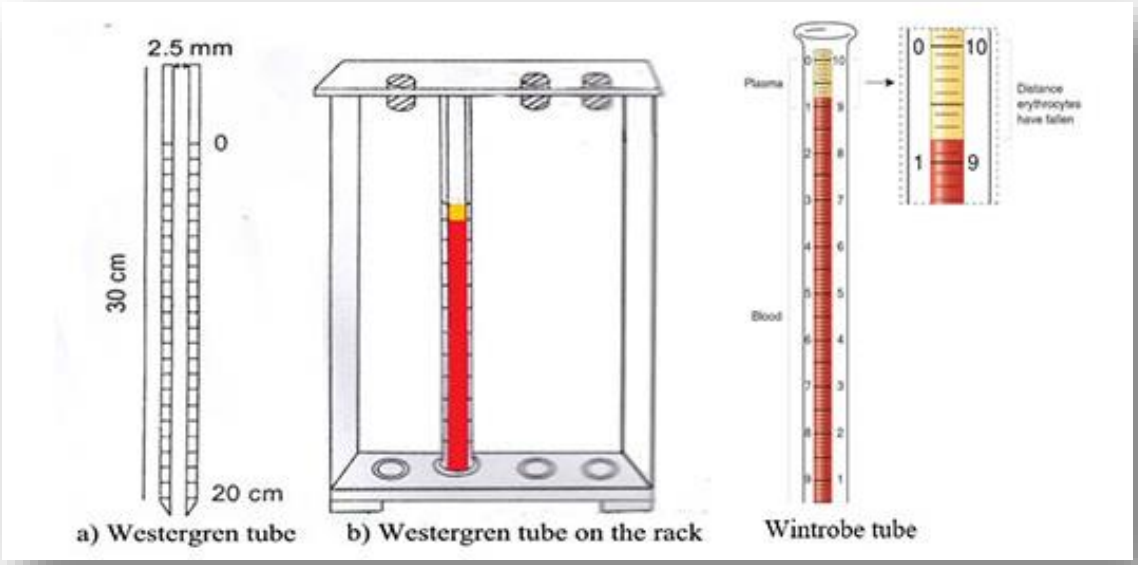
There are two main methods to determine ESR :

Westergren Method

- Widely used method for ESR estimation. **It is the method that we are going to use in today lab.**

Wintrobe Method

- Also used for ESR determination. Wintrobe tube is smaller than Westergren tube.



Material and Instruments of Westergren Method

- Westergren pipette (30 cm in length and 2 mm in diameter). It is graduated and open at both ends. The lower 20 cm are marked with 0 at the top and 200 at the bottom.
- Westergren pipette rack equipped with levelling screws.
- 3.8 % Sodium Citrate as anticoagulant in a ratio of 1:4 with blood.
- Plain test tubes 13× 100 mm.
- Syringe for withdrawal blood from the vein of the subject/patient.

ESR Pipette and Rack

Procedure

- Put 0.4 cc of Sodium Citrate in a plain test tube.
- Withdraw 2 cc of blood from the patient vein using a syringe.
- Immediately, add 1.6 cc of blood from the syringe in the plain tube and shake the tube for 2 min to ensure a good mixing of blood with Sodium Citrate.
- Fill the Westergren pipette exactly to 0 mark, make sure that there are no air bubbles at all in the blood.
- Place the pipette vertically on the rack and leave it undisturbed for 60 min. Avoid any vibration to the tube and do not expose it to a direct sunlight.
- At the end of the 60 min, read the number of millimeter the RBCs have fallen (i.e the height of clear plasma above the upper limit of the column of the sedimentating cells).
- Read the results in mm/hr.

Westergren Method Versus Wintrobe Method

Note: Wintrobe method has the same procedure as Westergrem method except that at the end of the one hour the tube is centrifuged at 2000-3000 rpm to complete the separation of RBCs which enables us to get the PCV value .

Advantages	Disadvantages
✓ Westergren Method is More reliable than Wintrobe method and gives accurate result.	In Westergren Method: ➢ More blood is required. ➢ Difficult to fill blood in the tube. ➢ PCV cannot be done. ➢ Mouth pipetting can be hazardous.

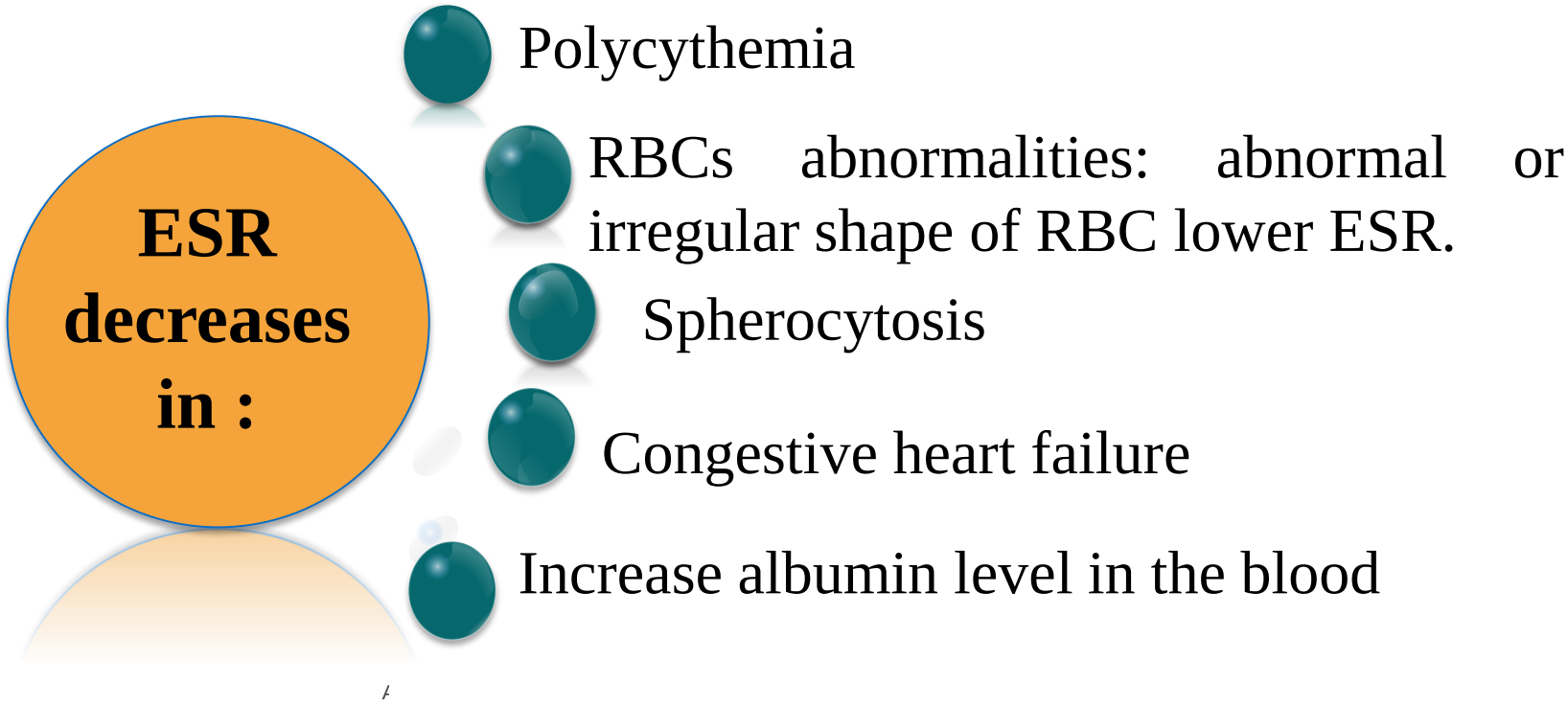
Clinical Implications

ESR increases in :

- ✓ **Anemia**
  - Anemia increases ESR because the change in erythrocyte-plasma ratio favors rouleaux formation.
  - Rouleaux tends to decrease the surface area and accelerate ESR.
- ✓ **Increase the level of fibrinogen**
- ✓ Increase cholesterol level
- ✓ Rheumatoid arthritis
- ✓ Acute and chronic infections
- ✓ Carcinoma
- ✓ Old age and Pregnancy (physiological not pathological)
- ✓ Tuberculosis
- ✓ Tissue destruction and other disease

Clinical Implications

ESR decreases in :



Technical Errors

Some Important Notes

- Because ESR determination is frequently performed in office laboratories , careful attention to some technical factors that may produce erroneous values is important.
- A tilted ESR tube, an increase in the temperature, and sample dilution can cause an ***artefactual elevation***.
- Inadequate anticoagulants with a clotting in the blood sample (consequently will consume fibrinogen), short ESR tube, and vibration during the test may ***artifictually lower the ESR.***

Extreme Elevation of ESR

- An ***extreme elevation in ESR*** (***defined as greater than 100 mm/hr***)is associated with a low false positive rate for serious underlying diseases. The conditions found in this situation have varied in individual populations depending on the patient age and inpatient versus outpatient status. In most series, **infection has been the leading cause of an extremely elevated value** followed by collagen vascular disease and metastatic malignant tumors. Renal disease has also been a notable etiological factor .
- Because most of these conditions are clinically apparent, any tests performed should be clinically driven. For instance, if symptoms of infection are present, the appropriate cultures, including urine and blood, and skin testing for tuberculosis should be obtained. An exhaustive search for an occult malignancy should not be undertaken because if cancer is present, it is almost always metastatic.
- No obvious cause is apparent in less than 2% of the patients with markedly elevated ESR. In such patients, the history and physical examination coupled with readily available tests will usually establish the etiology.
- Because a notable number of patients with ESR more than 100 mm/hr have myeloma or some other type of dysproteinemia, urine and protein electrophoretic studies should be included in the testing.

Sedimentation rate key facts:

- A high sedimentation rate signals high levels of inflammation in the body
- Most people with an autoimmune disease will have a high sed rate, but the test can't help diagnose a specific disease
- The sed rate test can help evaluate how well your treatments are working