Erythrocyte Sedimentation Rate, Procedure and Interpretations

The **erythrocyte sedimentation rate (ESR)** is a simple, non-specific hematological test that measures the rate at which erythrocytes (red blood cells) settle in a vertical column of anticoagulated blood over one hour. It serves as an indirect marker of inflammation and is widely used to support the diagnosis and monitoring of various pathological conditions.

Principle of ESR

The principle of the ESR test is based on the fact that erythrocytes are denser than plasma. When blood is anticoagulated and placed vertically in a calibrated tube, gravity causes the erythrocytes to settle over time. The distance (in mm) between the top of the plasma column and the top of the sedimented red cell column is measured after one hour. This distance is reported as mm/hr.

The rate of sedimentation depends on the plasma protein composition, particularly acute-phase reactants like **fibrinogen** and **?-globulins**, which promote **rouleaux formation**—stacks of red cells that settle more rapidly.

Phases of Erythrocyte Sedimentation

ESR occurs in three distinct phases:

1. **Aggregation Phase (First 10 Minutes)**
    - Rouleaux (coin-stack) formation due to altered zeta potential from acute-phase proteins.
2. **Sedimentation Phase (Next 40 Minutes)**
    - Rapid and steady downward settling of erythrocyte aggregates under gravity.
3. **Packing Phase (Final 10 Minutes)**
    - Slowing of sedimentation as red cells pack at the bottom of the tube.

Methods of Measuring ESR

1. Westergren Method

- **Standardized by:** International Council for Standardization in Haematology (ICSH).
- **Procedure:** Uses a 200 mm long Westergren tube filled with diluted anticoagulated blood (usually with sodium citrate), placed vertically for 1 hour.
- **Reference values:**
    - Men: 0–15 mm/hr
    - Women: 0–20 mm/hr

Advantages:

- High sensitivity to detect changes in inflammation.
- Suitable for monitoring chronic diseases like tuberculosis or rheumatoid arthritis.

Disadvantages:

- Requires a larger volume of blood.
- Blood dilution may introduce errors if not done correctly.

2. Wintrobe Method

- **Tube specifications:** 100 mm long, 2.5 mm internal diameter, closed at one end.
- **Procedure:** Uses undiluted anticoagulated blood (usually EDTA) and placed in a specialized Wintrobe rack.

Advantages:

- Requires a smaller blood volume.
- No dilution needed.
- Simultaneous estimation of hematocrit possible.

Disadvantages:

- Less sensitive, especially when ESR is elevated.
- Shorter column limits measurement range.

Factors Affecting ESR

I. Plasma Proteins

- ESR is influenced by the balance of plasma proteins.
- **Increased fibrinogen, ?-globulins, and immunoglobulins** reduce zeta potential, promoting rouleaux formation and faster sedimentation.
- **High albumin** inhibits rouleaux formation, slowing ESR.

II. Plasma Viscosity

- Plasma viscosity and ESR usually increase together, but extremely viscous plasma (e.g., in hypergammaglobulinemia) may paradoxically reduce ESR due to resistance to red cell movement.

III. Red Blood Cell Factors

- **Anisocytosis and poikilocytosis** interfere with rouleaux formation, lowering ESR.
- **Anemia** increases ESR due to reduced red cell mass, facilitating aggregation.
- **Polycythemia** decreases ESR due to increased cell concentration.

IV. Technical/Mechanical Factors

- Non-vertical tube placement can falsely elevate ESR.
- Vibrations or tilting can disturb red cell sedimentation.

V. Temperature

- Higher temperatures lower plasma viscosity, falsely increasing ESR.
- Optimal testing temperature: **18–25°C**.

Clinical Significance of ESR

Elevated ESR is associated with:

- **Infections** (e.g., tuberculosis, bacterial endocarditis)
- **Inflammatory disorders** (e.g., rheumatoid arthritis, systemic lupus erythematosus)
- **Malignancies** (e.g., lymphoma, multiple myeloma)
- **Autoimmune diseases**
- **Anemia**
- **Chronic kidney and liver diseases**

Physiological increases occur in:

- **Pregnancy**
- **Menstruation**
- **Advanced age**
- **Post-exercise**
- **Postprandial state (after meals)**
- **Following hot baths**

Limitations of ESR

- **Non-specific test**: Does not indicate the specific location or cause of inflammation.
- **Lag in response**: ESR may remain elevated for weeks after the resolution of inflammation.
- Should be interpreted **in conjunction with clinical findings and other investigations** such as **C-reactive protein (CRP)** for a more accurate inflammatory profile.

High-Yield Points

- ESR is a **screening tool**, not diagnostic on its own.
- **Westergren method** is the gold standard.
- **Acute-phase reactants** heavily influence ESR.
- **ESR is elevated in many non-inflammatory and physiological states**, so context is critical.
- Always **correlate ESR with clinical presentation** and other inflammatory markers.