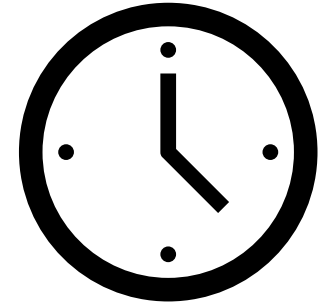
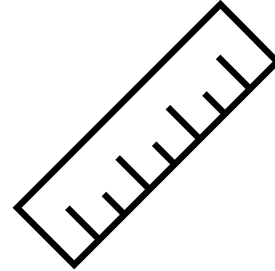
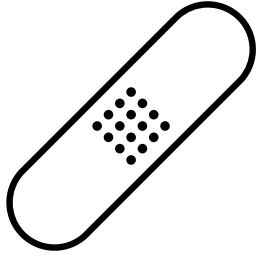




Physiology of the Blood and Lymphoreticular System

Lab (1) – Medical and Dental Students – 2026/2027

- Packed cell volume (PCV)
- Erythrocyte Sedimentation rate (ESR)

Dr. Abdullah Al-Jaouni

Packed Cell Volume (PCV)



PCV – What to Know



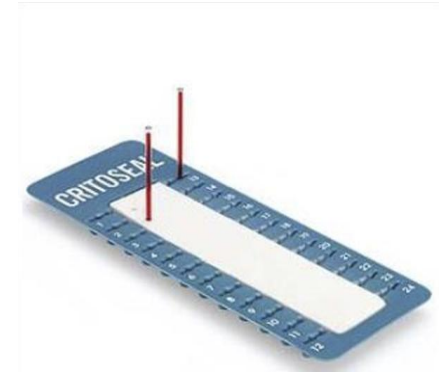
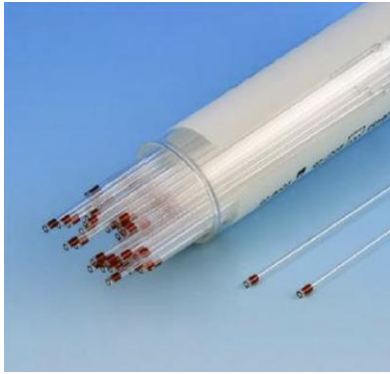
PCV is the ratio of the volume of packed red cells to the total blood volume. (*Remember: What is Blood?*)

Adult males: 40–54% (avg = 47%).

Adult females: 38–46% (avg = 42%).



It decreases in cases of anemia and increases in polycythemia and dehydration.



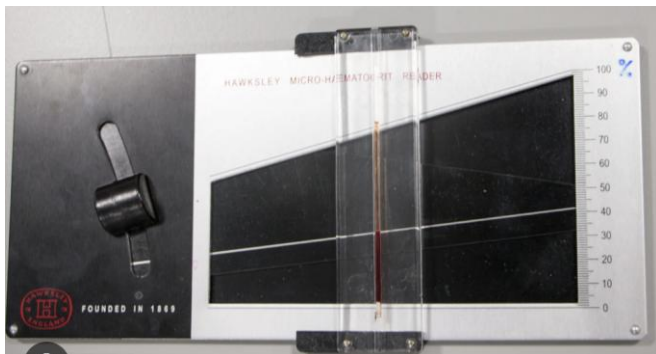
PCV – The Procedure

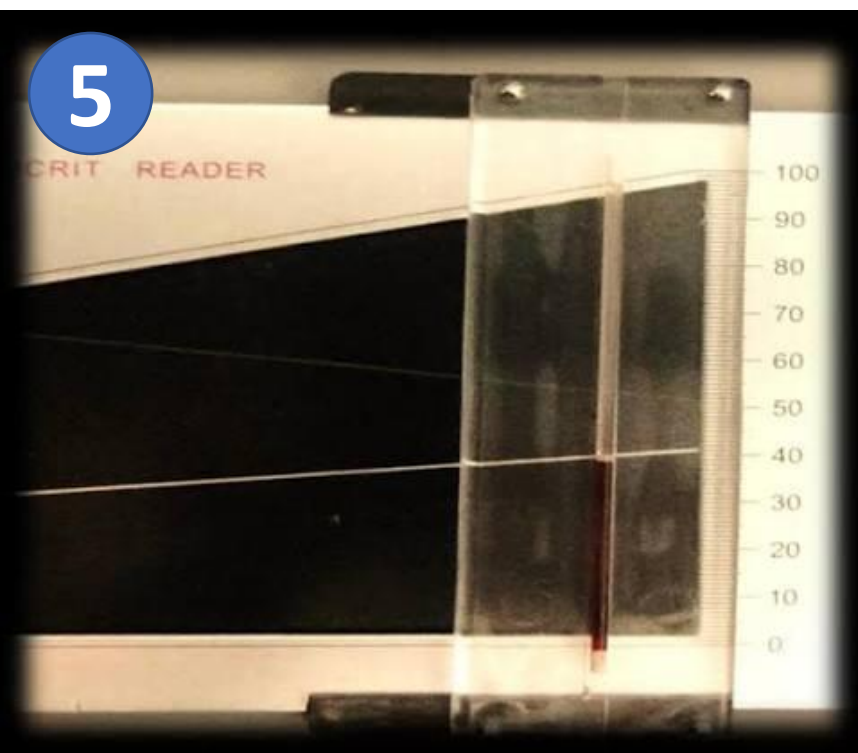
- Tools:

- Heparinized capillary tube, Blood source, Clay, Micro-centrifuge, and a Ruler.

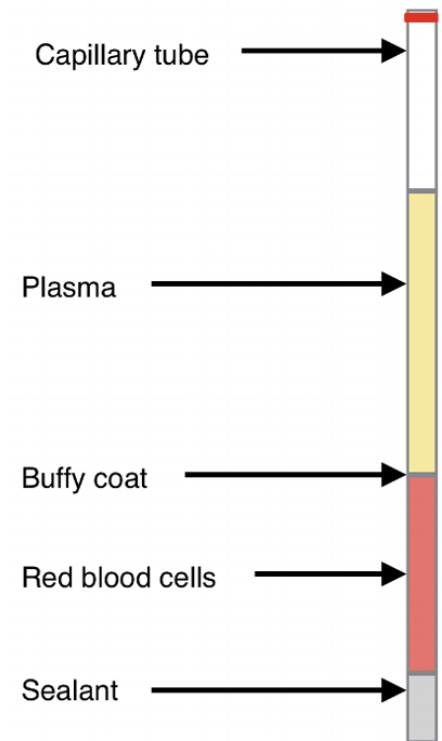
- Steps:

1. A gloved hand draws blood up the capillary tube via capillary action. The tube is filled with blood by capillary action to about $\frac{3}{4}$ of its capacity as control is maintained with a finger at the top.
2. The filled tube is then pressed firmly vertically into the clay block to create a secure plug at the bottom.
3. The tube is then placed into the rotor. *It is critical to load the tubes symmetrically, so the rotor is balanced before centrifugation.*
4. After a 5-minute spin cycle, the tube is extracted from the centrifuge.
5. Then, it is placed alongside a ruler to measure the RBC column height and the total height, and so the PCV.





The PCV is then calculated according to the following formula:

$$\text{PCV} = (\text{RBC height} / \text{Total height}) \times 100$$


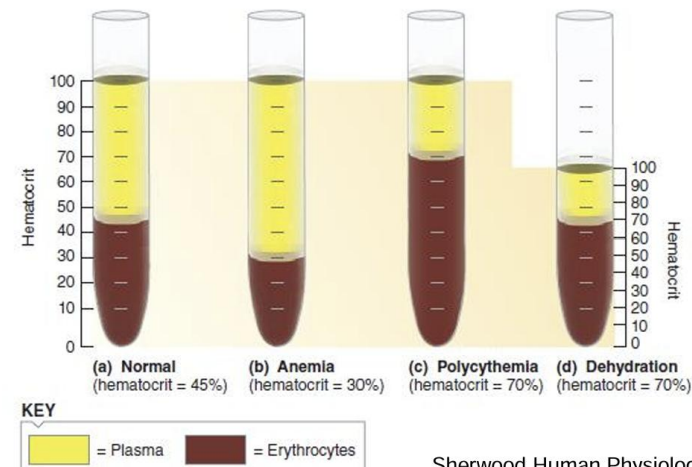
PCV — Interpretation and Clinical Significance

Decreased PCV:

- Anemia
 - Increased RBC loss:
 - Internal or external bleeding
 - Increased RBC destruction (Hemolytic anemia)
 - Decreased RBC production:
 - Nutritional deficiencies
 - Bone marrow failure
 - Chronic renal failure

Increased PCV:

- Polycythemia
 - Primary: Polycythemia Vera (Erythropoietin is normal or low)
 - Secondary: Living at high altitudes, Cardiac or pulmonary diseases (Erythropoietin is high)
- Dehydration





Erythrocyte Sedimentation Rate (ESR)

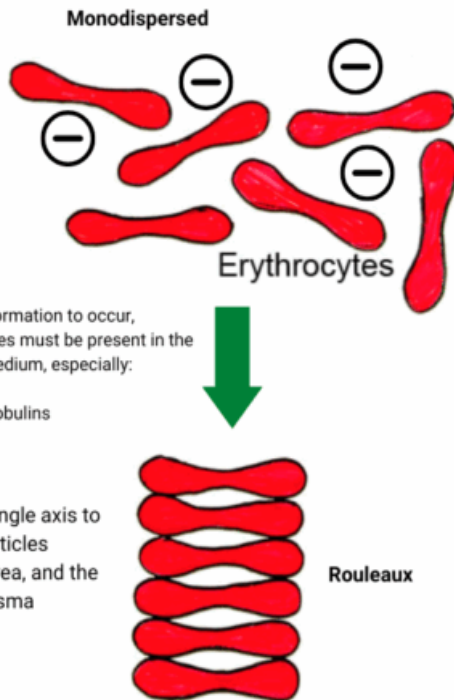
ESR – What to Know

Normally, rouleaux formation is limited by the **negative charge on the red blood cell** conferred by cell surface sialic acid (zeta potential). If this charge is neutralized, RBC stack into chains, or rouleaux, and fall more rapidly.

For rouleaux formation to occur, macromolecules must be present in the suspending medium, especially:

- Fibrinogen
- Immunoglobulins

When red cells aggregate along a single axis to **form rouleaux**, the weight of the particles increases relative to their surface area, and the red cells' rate of fall through the plasma increases



1. Definition & Clinical Value

- **Definition:** The rate (mm/hr) at which RBCs settle in anticoagulated whole blood over **one hour**.
- **Clinical Value:** **Highly sensitive**, but **non-specific** indicator of systemic inflammation.

2. Pathophysiology & Mechanism

- **Sedimentation Driver:** RBCs are denser than plasma and naturally settle over time.
- **Normal State (Charge Repulsion):**
 - RBCs carry a **negative surface charge** (zeta potential) that repels them from one another, preventing aggregation and keeping the ESR low.
- **Inflammatory State (Rouleaux Formation):**
 - Inflammatory acute-phase proteins (**fibrinogen, immunoglobulins**) carry **positive charges**.
 - These proteins neutralize the negative RBC surface charges, allowing the biconcave discs to stack into clusters (**rouleaux formation**).
 - Stacking increases effective mass, causing faster settling and an **elevated ESR**.

ESR – The Procedure

- Tools:
 - ESR tubes (special tubes that have the zero mark on top), EDTA anticoagulated blood.
- Steps:
 1. EDTA anticoagulated blood is drawn into the ESR tube till the zero mark. The tube is placed in its rack in a strictly vertical position for 1 hour at room temperature.
 2. The RBCs, under the influence of gravity, settle out from the plasma, and this will leave a clear, straw-colored fluid (plasma) at the top of the tube.
 3. The rate at which they settle is measured as the number of millimeters of clear plasma present at the top of the RBC column after one hour (mm/hr).



ESR – Interpretation and Clinical Significance

Normal:

Categories	Normal ESR test results (mm/hr.)	Abnormal ESR test results (mm/hr.)
Females < 50 age	0 - 20	> 20
Males < 50 age	0 - 15	>15
Females > 50	0 - 30	>30
Males > 50	0 - 20	>20
Children (before puberty)	0 - 10	>10
Newborn	<2	>2

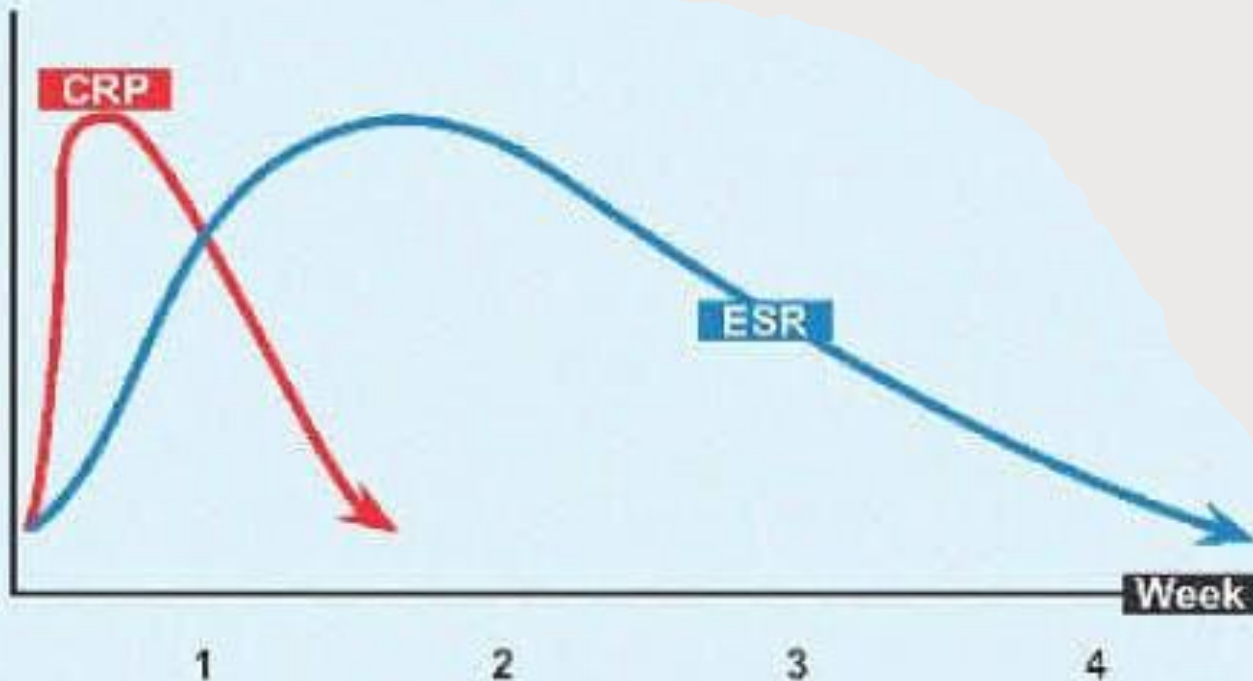
High:

- Inflammation.
- Anemia.
- Old age.
- Pregnancy.
- Technical factors: Tilted ESR tube, High room temperature.

Low:

- Abnormally shaped RBC (sickle cells and spherocytosis).
- Polycythemia.
- Technical factors: Low room temperature, Delay in test performance (>2 hours), Clotted blood sample

ESR – When to Reassess



- Unlike **C-reactive protein (CRP)**, which rises within hours and has a rapid clearance half-life (~19 hours), **ESR changes slowly** because it relies on plasma proteins—predominantly **fibrinogen**—which have long circulating half-lives (~4 to 7 days).
- Thus, re-checking ESR within 1–7 days is clinically unhelpful because ESR lags significantly behind clinical improvement. In this period, other parameters and proteins are used for reassessment.
- ESR is rechecked in **2 to 4 weeks** if needed.

Thank You
