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Complete Blood Count (CBC): Interpretation and Clinical Relevance

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LEARNING OUTCOMES

After completing this session, students will be able to:

1. Define the components of a CBC.

2. Explain the physiological importance of each component.

3. Interpret abnormal CBC values in clinical contexts.

CONTENTS

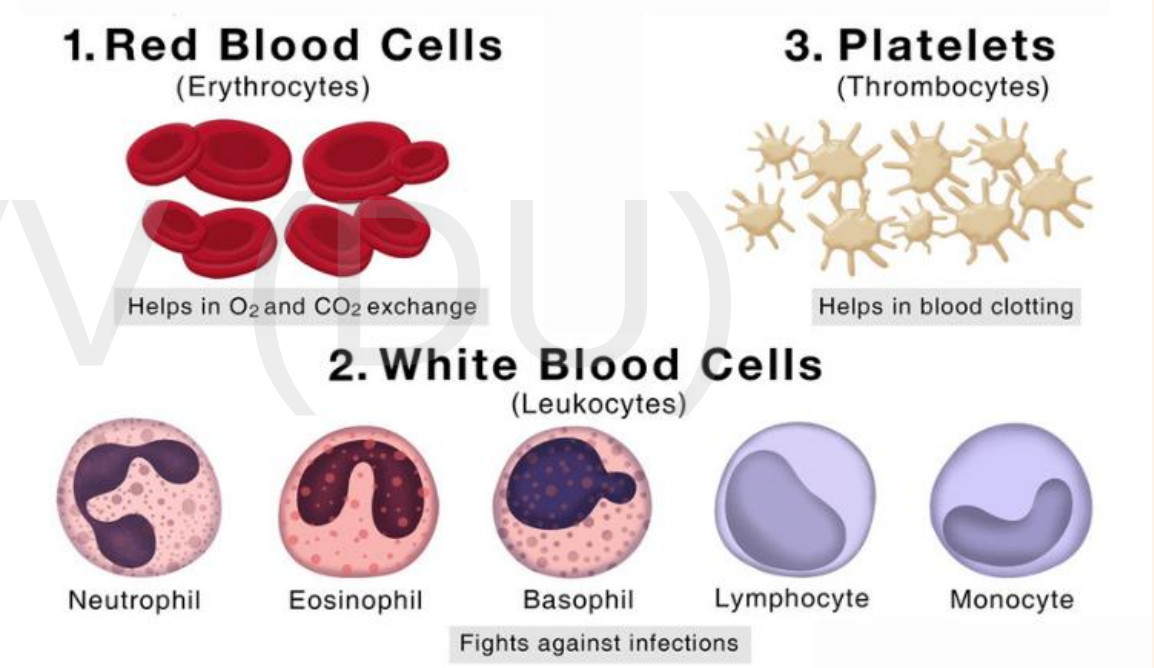
- ❑ Definition & Components of CBC
- ❑ Overview of CBC and its purpose
- ❑ Key components: RBCs, WBCs, Platelets, and related indices
- ❑ RBC Parameters & Clinical Relevance
- ❑ WBC Parameters & Clinical Relevance
- ❑ Platelet Parameters & Clinical Relevance
- ❑ Reticulocyte count, ESR, and their clinical significance
- ❑ Summary & Applications

DEFINITIONS AND Its COMPONENTS

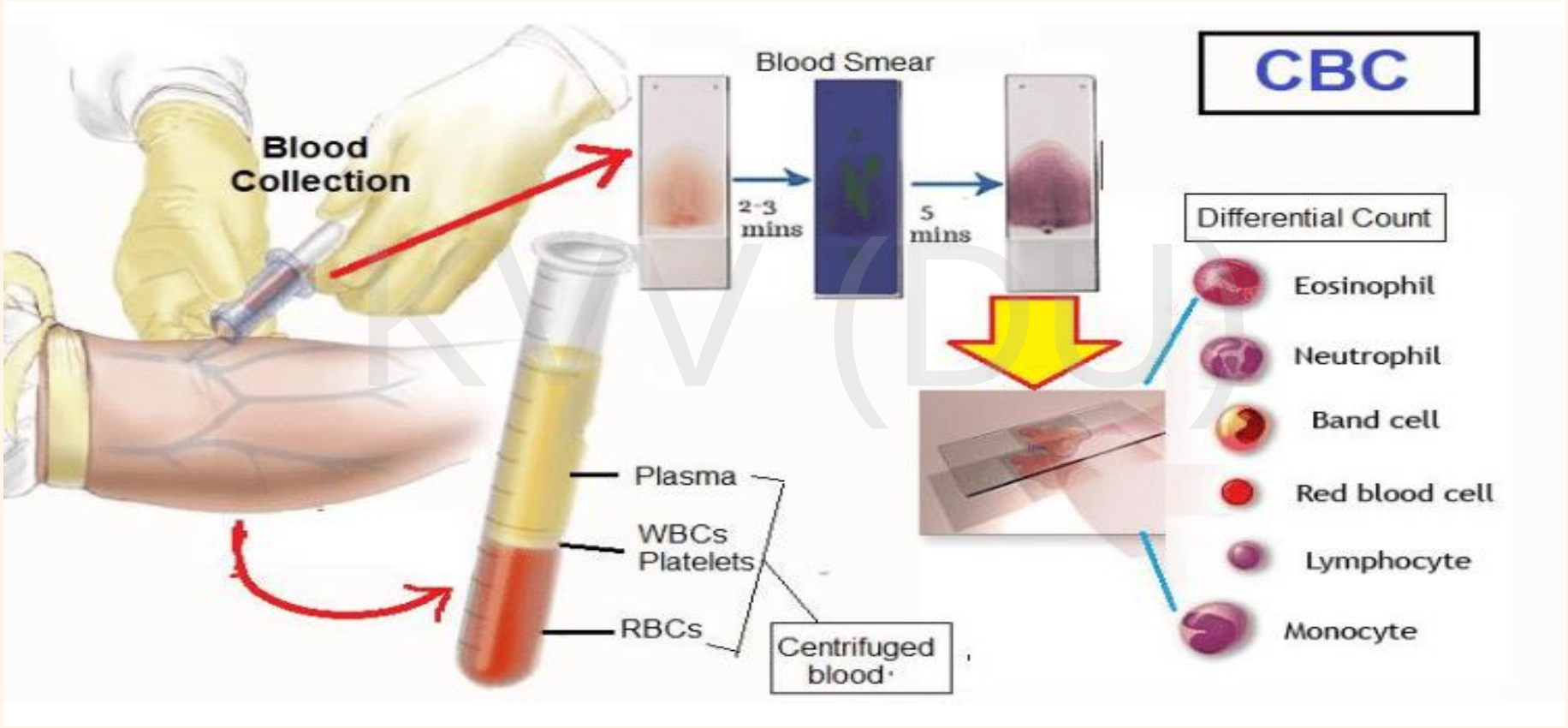
Definitions:

A hematology test or complete blood count or full blood count that evaluates the quantity and quality of blood cells.

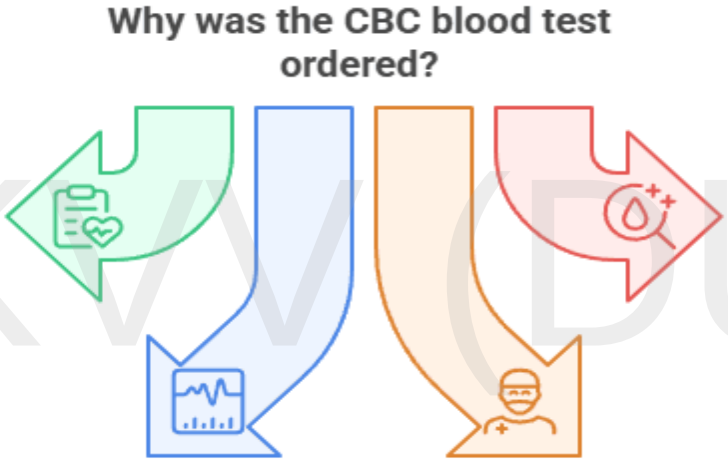
A Complete Blood Count (CBC) is a common blood test.



How CBC is performed?



PURPOSE of CBC or FBC or Hematological Tests



Routine Health Check-ups

To monitor general health and screen for potential issues early on.

Diagnosing Medical Conditions

To identify causes of symptoms like fatigue or bruising.

Monitoring Existing Conditions

To track disease progress or treatment effectiveness.

Pre-Surgery Evaluation

To ensure health and identify bleeding risks before surgery.

Components of CBC/FBC/Hematological TESTS

A CBC typically includes:

- ❑ RBC count
- ❑ hematocrit (Hct)
- ❑ hemoglobin (Hb)
- ❑ RBC indices (mean cell volume [MCV]
- ❑ mean cell Hb [MCH]
- ❑ mean cell Hb concentration [MCHC])
- ❑ reticulocyte count
- ❑ Total WBC count
- ❑ platelet count

RBCs COUNT (erythrocytes): Physiological Functions

Function	Mechanism
O_2 Transport	Hemoglobin binds O_2 in lungs, releases it in tissues.
CO_2 Transport	As bicarbonate (70%), carbaminohemoglobin (20%), dissolved in plasma (10%).
pH Regulation	Buffers H^+ ions via hemoglobin, maintains acid-base balance.
NO Transport	Releases nitric oxide for vasodilation.
Blood Flow Optimization	Biconcave shape ensures flexibility and efficient microcirculation.

RBCs COUNT (erythrocytes)

The RBC count, which reports the number of red blood cells (RBCs) found in a given volume of blood, provides an indirect estimate of the blood's Hb content.

Values are often reported in cells/microliter (L)
or cells/liter and less commonly as cells/cubic millimeter (mm^3).

Normal values are

- 4.3 to 5.9 10^{12} cells/L of blood for men
- 3.5 to 5.0 10^{12} cells/L of blood for women

Clinical Relevance of RBCs (erythrocytes) COUNT

Anemia (low RBCs/Hb) → Reduced O_2 delivery → Fatigue, hypoxia.

Polycythemia (high RBCs) → Increased blood viscosity → Risk of clots.

Sickle Cell Disease → Abnormal Hb → Poor O_2 transport & blockages.

Hct or PACKED CELL VOLUME (PCV)

Measures the percentage by volume of packed RBCs in a whole blood sample after centrifugation.

The Hct value is usually three times the Hb value and is given as a percent or fraction of 1 (42% to 52% or 0.42 to 0.52 for men; 37% to 47% or 0.37 to 0.47 for women).

- Low Hct values indicate such conditions as anemia, overhydration, or blood loss.
- High Hct values indicate such conditions as polycythemia vera or dehydration.

HEMOGLOBIN TEST

The Hb test measures the grams of Hb contained in 100 mL (1 dL) or 1 L of whole blood and provides an estimate of the oxygen-carrying capacity of the RBCs.

The Hb value depends on the number of RBCs and the amount of Hb in each RBC.

- Normal values are 14 to 18 g/dL for men and 12 to 16 g/dL for women.
- Low Hb values indicate anemia.

CLINICAL RELEVANCE OF HEMOGLOBIN TEST

Grading of Anemia Severity

Population	Mild anemia (g/dL)	Moderate anemia (g/dL)	Severe anemia (g/dL)
Men	11 - 12.9	8 - 10.9	<8
Non-pregnant woman	11 - 11.9	8 - 10.9	<8
Pregnant woman	10 - 10.9	7 - 9.9	<7

RBC INDICES

Measures

- ❑ RBC size
- ❑ Hb concentration
- ❑ Hb weight

They are used primarily to categorize anemias.

- variation in RBC shape (poikilocytosis),
- variation in RBC size (anisocytosis),
- mixed anemia (folic acid and iron deficiency).

MEAN CORPUSCULAR VOLUME (MCV)

$$MCV = \frac{\text{Hct (\%)} \times 10}{\text{RBC (millions)}}$$

Normal range for MCV is 90±10

CLINICAL RELEVANCE

- **Low MCV:** microcytic (undersize) RBCs, as occurs in iron deficiency.
- **High MCV:** macrocytic (oversize) RBCs, as occurs in a vitamin B12 or folic acid deficiency.

MEAN CELL HEMOGLOBIN (MCH)

$$MCH = \frac{Hb \times 10}{RBC\ (millions)}$$

Normal range **27–31 picograms (pg) per RBC**

CLINICAL RELEVANCE

- **High MCH (>31 pg):** Macrocytic anemia
- **Low MCH (<27 pg) :** Microcytic anemia

MEAN CELL HEMOGLOBIN CONCENTRATION (MCHC)

$$MCHC = \frac{Hb \times 100}{Hct}$$

Measures Hb per unit volume of RBCs

Normal range for MCHC is 34±3 g/dl

CLINICAL RELEVANCE

Low MCHC: hypochromia (pale RBCs resulting from decreased Hb content) : Iron deficiency anemia. Other possible causes: lead poisoning, anemia of chronic disease, thalassemias, sideroblastic anemia.

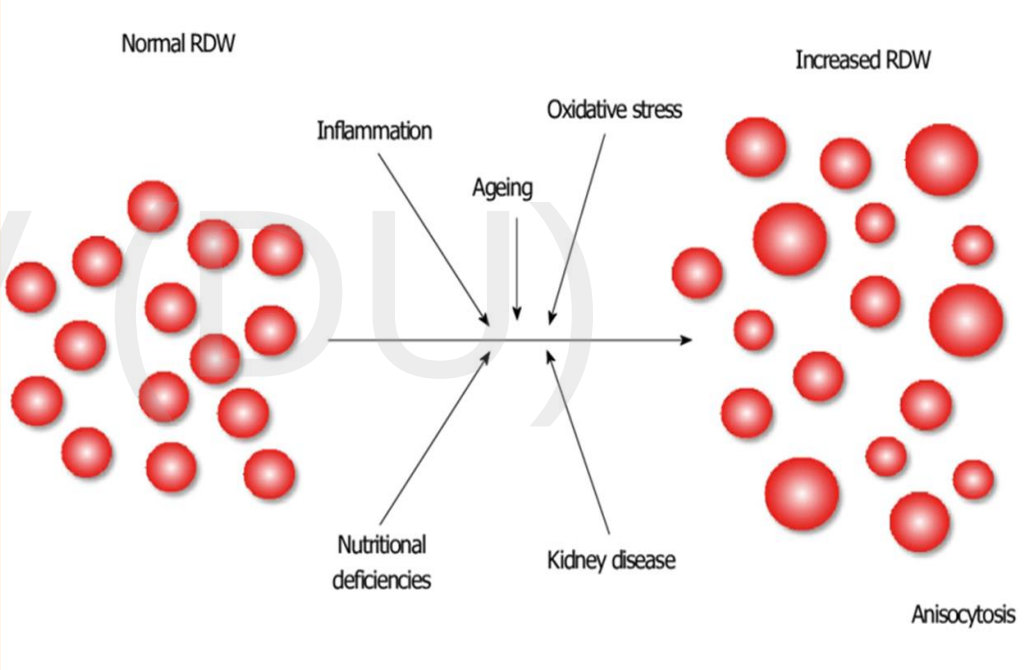
RED BLOOD CELL DISTRIBUTION WIDTH (RDW)

RDW measure of the variation in the size of red blood cells

CLINICAL RELEVANCE

- Increased RDW: Anemia (e.g., iron, folate, vitamin B12).
- Normal RDW: conditions as anemia of chronic disease.

The RDW index is never decreased.



RETICULOCYTE COUNT

- Measure of immature RBCs (reticulocytes), which contain remnants of nuclear material (reticulum) index of bone marrow production of mature RBCs.
- **Increased reticulocyte count:** hemolytic anemia, acute blood loss, and response to the treatment of a factor deficiency (e.g., an iron, vitamin B12, or folate deficiency).
- **Decreased reticulocyte count:** Drug-induced aplastic anemia.

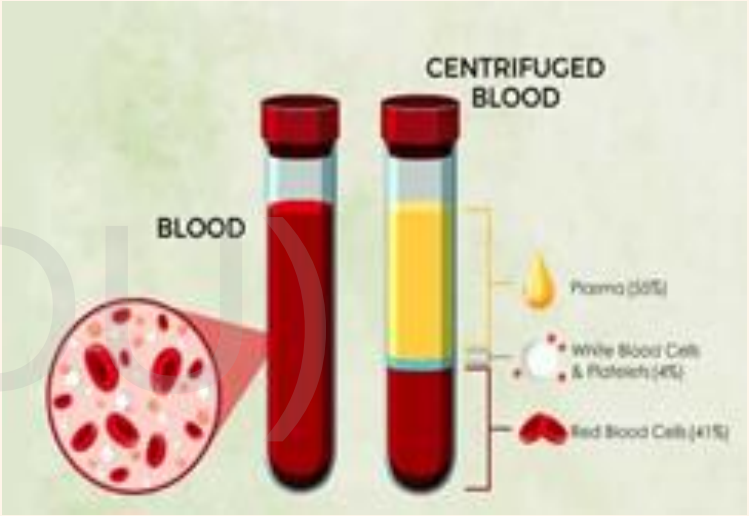
High count + anemia → Effective marrow response (e.g., hemolysis).

Low count + anemia → Ineffective erythropoiesis (e.g., aplasia, deficiency).

ERYTHROCYTE SEDIMENTATION RATE (ESR)

The erythrocyte sedimentation rate (ESR) measures the rate of RBC settling of whole, uncoagulated blood over time, and it primarily reflects plasma composition.

Normal ESR rates: 0 to 20 mm/hr for males; 0 to 30 mm/hr for females.



Clinical Relevance

ESR values increase: acute or chronic infection, tissue necrosis or infarction, well-established malignancy, and rheumatoid collagen diseases.

USE OF ERYTHROCYTE SEDIMENTATION RATE (ESR)

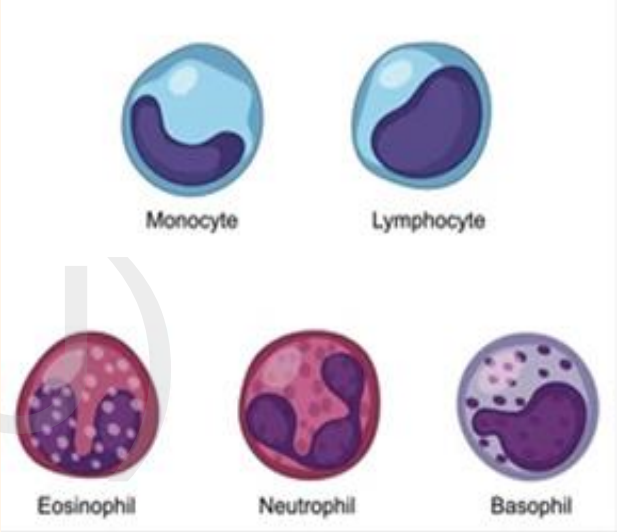
ESR values are used to

(1) Follow the clinical course of a disease
(2) Demonstrate the presence of occult organic disease
(3) Differentiate conditions with similar symptomatology—for example, angina pectoris (no change in ESR value) as opposed to a myocardial infarction (increase in ESR value).

LEUCOCYTES (WBC) COUNT

The WBC count reports the number of leukocytes in a given volume of whole blood.

Normal values range: 4,000 to 11,000 × 10^3 cells/mm^3 (or 10^9 cells/L)

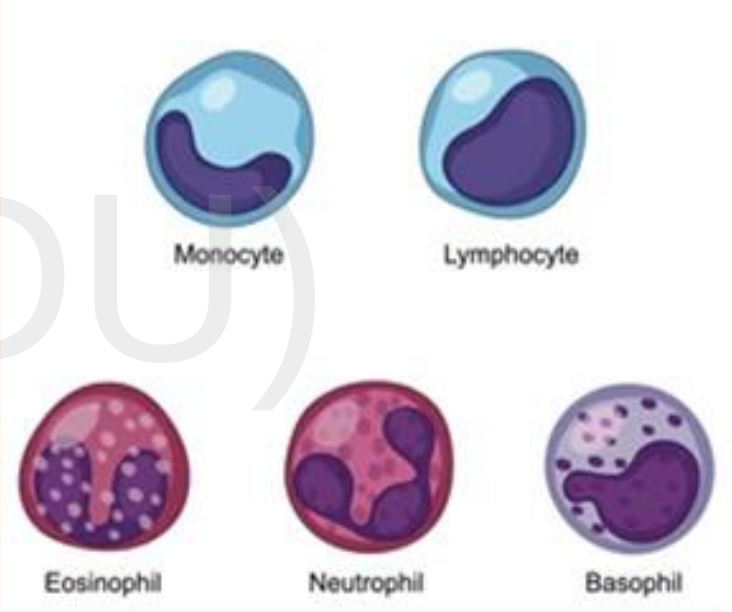


- Increased WBC count (leukocytosis): infection; leukemia, tissue necrosis, or administration of corticosteroids.
- Decreased WBC count (leukopenia): metastatic carcinoma, lymphoma, or toxic reactions to substances such as antineoplastic agents.

TYPES OF WBC or DIFFERENTIAL COUNT

Distribution and morphology of the five major types of WBCs:

- Granulocytes: neutrophils, basophils, eosinophils
- Nongranulocytes: lymphocytes, monocytes



TYPES OF WBC or DIFFERENTIAL COUNT

Function	Mechanism	Key Cells Involved
Infection Defense	Phagocytosis, antibody production, toxin release	Neutrophils, macrophages, B/T cells
Inflammation Regulation	Cytokine release, histamine, prostaglandins	Basophils, eosinophils, monocytes
Cancer & Viral Defense	Direct killing (NK cells, cytotoxic T cells)	NK cells, CD8+ T cells
Wound Healing	Clear dead cells, promote tissue repair	Macrophages, monocytes
Immune Memory	Remember pathogens for faster future response	B & T memory cells

CLINICAL RELEVANCE OF WBC DIFFERENTIAL COUNT

Cell Type	Normal Range (%)	Clinical Relevance
Polymorphonuclear leukocytes (PMNs/Neutrophils)	50–70	↑ in bacterial infections
Bands (immature neutrophils)	3–5	↑ ("shift to the left") = acute infection.
Lymphocytes	20–40	↑ (**Lymphocytosis**): Viral infections (e.g., mononucleosis). ↓ (**Lymphopenia**): AIDS (targets T_4 cells), severe illness.
Monocytes	0–7	↑ (**Monocytosis**): TB, subacute bacterial endocarditis.
Eosinophils	0–5	↑ (**Eosinophilia**): Allergies, parasitic infections.
Basophils	0–1	↑ (**Basophilia**): Chronic myelogenous leukemia (CML).

TYPICAL LAB REPORT OF WBC DIFFERENTIAL COUNT

Key Pathological Patterns
Example: Bacterial Infection Response

Cell Type	Normal WBC Count (%)	With Bacterial Infection (%)
Total WBCs	8,000 (100%)	15,500 (100%)
Neutrophils (PMNs)	60%	82%
Bands	3%	6%
Lymphocytes	30%	10%
Monocytes	4%	1%
Eosinophils	2%	1%
Basophils	1%	0%

PLATELETS (THROMBOCYTES)

Key Functions

- ❑ Involved in **blood clotting**
- ❑ Essential for **hemostatic plug formation** after vascular injury

Normal Values: Platelet count: 150,000 to 300,000/mm³ (or 1.5 to 3.0 × 10^{11}/L)

Severity Classification:

Moderate: <100,000/mm³

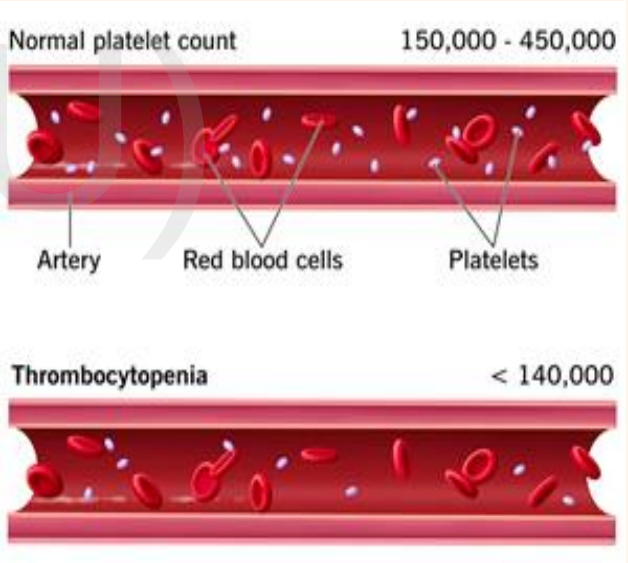
Severe: <50,000/mm³ (high risk of spontaneous bleeding)

Thrombocytopenia (Decreased Platelet Count)

Causes:

Idiopathic thrombocytopenic purpura (ITP)

Drug reactions (e.g., quinidine, sulfonamides)



Report: Complete blood count (CBC)-Test Result, Unit, Reference Range

Test Name	Result	Unit	Reference Range
CBC (Complete Blood Count) **(Automated Cell Counter, Electric Impendance)**			
Total Leukocyte Count	4240	/cumm	4000 - 11000
Differential Leukocyte Count			
Neutrophil	51	%	40 - 70
Lymphocyte	35	%	20 - 45
Monocyte	8	%	2 - 10
Eosinophil	5	%	1 - 6
Basophil	1	%	0 - 1
Haemoglobin	**7.2**	gm%	12.0 - 16.0
Packed Cell Volume / Hct	**23.1**	%	35.0 - 47.0
Red Blood Cells Count	**3.42**	millions/cumm	3.80 - 5.80
Mean Corpuscular Volume (MCV)	**67.5**	fL	80.0 - 100.0
Mean Corpuscular Haemoglobin (MCH)	**21.1**	pg	26.0 - 36.0
Mean Corpuscular Hb Concentration (MCHC)	31.2	g/dL	31.0 - 37.0
Platelet Count	**142000**	/cumm	150000 - 450000

THANK YOU