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Interpreting a Complete Blood Count



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Learning Goals

- After this course, the learner will be able to:
 - State and describe the components of a complete blood count
 - Calculate the Red Blood Cell (RBC) indices and correlate with peripheral blood smear
 - Apply a systematic approach to summarize the complete blood count

Components of the Complete Blood Count

- White Blood Cell (WBC) count
- Red Blood Cell (RBC) count
- Hemoglobin (HGB)
- Hematocrit (HCT)
- RBC Indices
 - Mean Cell Volume (MCV)
 - Mean Cell Hemoglobin (MCH)
 - Mean Cell Hemoglobin Concentration (MCHC)
- Red Cell Distribution Width (RDW)
- Platelet Count and Mean Platelet Volume (MPV)

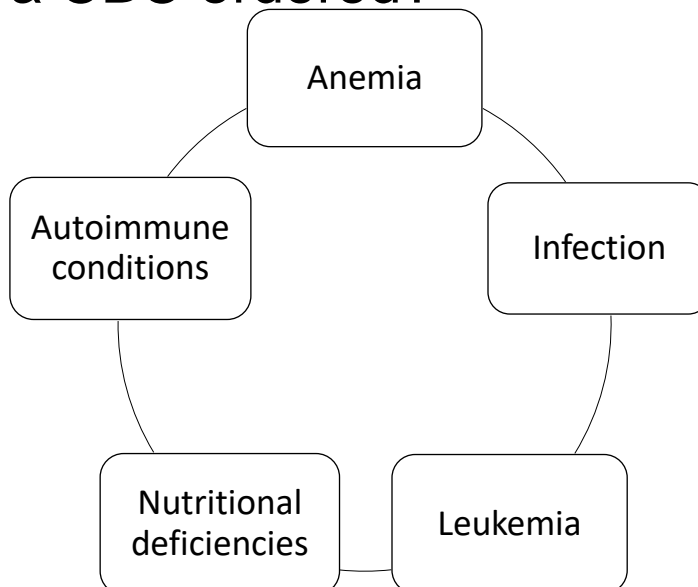
The Complete Blood Count (CBC)

White Blood Cell Parameters

Red Blood Cell Parameters

Platelet Parameters

Why is a CBC ordered?



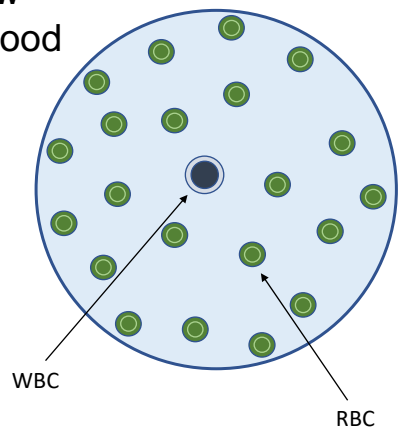
WBC Parameters

Total WBC Count

WBC Differential

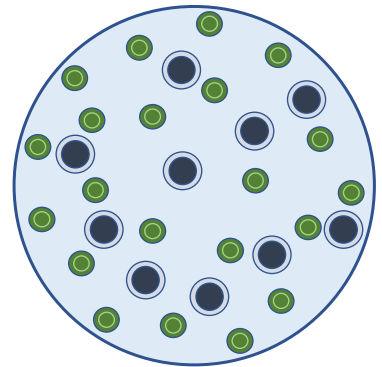
White Blood Cell (WBC) Count

- Leukocytopenia, $WBC = < 4.5 \times 10^9/L$
 - Decreased production in the bone marrow
 - Increased destruction in the peripheral blood
 - Sepsis
 - Chemotherapy
 - Aplastic anemia



White Blood Cell (WBC) Count

- Leukocytosis, WBC = $> 11.5 \times 10^9/L$
 - Infections
 - Stress
 - Some leukemias
 - Trauma
 - Certain medications or chemicals

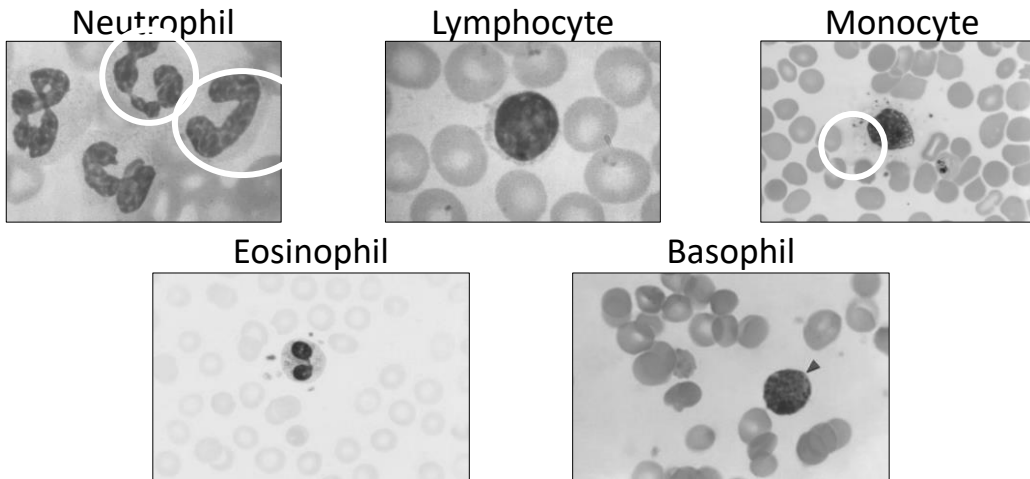


WBC Differential

Relative vs. Absolute

Amount of a cell type in relation to other blood components	% Relative	WBC Subtype	# Absolute	The 'actual' number of the particular cell per liter of blood
	71.1	Neutrophil	8.5	Sum equals the total WBC Count
	15.9	Lymphocyte	1.9	
	3.8	Monocyte	0.5	
	0.5	Eosinophil	0.1	
Totals 100%	8.7	Basophil	1.1	

WBC Subtypes



RBC Parameters

RBC Count, HGB, and HCT

RBC Indices

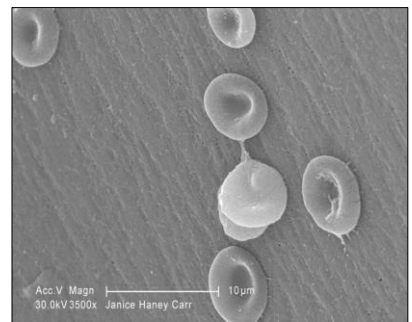
Red Blood Cell Distribution Width

RBC Parameters

- The CBC tells us:
 - The number of RBCs
 - The amount of hemoglobin present
 - The portion of blood that consists of RBCs – hematocrit
 - Information on the size and hemoglobin content of RBCs – RBC Indices
 - If there is any variation in size within the RBC population – RDW

Red Blood Cells, RBC = $4.00 - 6.00 \times 10^{12}/L$

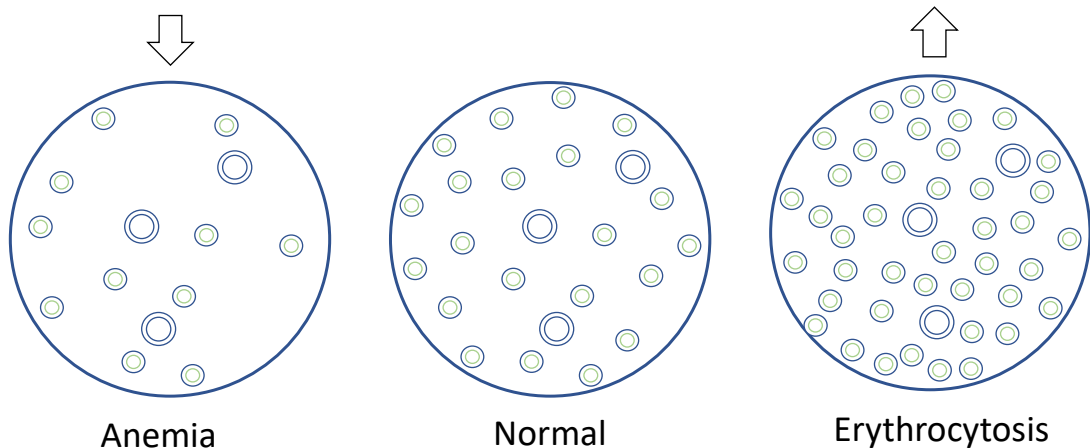
- Life span of 120 days
- Contain hemoglobin
- Microscopic:
 - Bi-concave discs
 - 6 – 8 microns in size
 - Reddish-pink color, lacking a nucleus



Hemoglobin and Hematocrit (H&H)

Hemoglobin	Hematocrit
<p>Found in all RBCs – iron containing protein</p> <p>Enables RBCs to bind oxygen</p> <p>One hemoglobin molecule can carry up to four O₂ molecules</p> <p>Reference Range:</p> <p>Female: 12.0 – 15.0 g/dL</p> <p>Male: 14.0 – 18.0 g/dL</p>	<p>Determines the ratio of RBCs to the total volume blood</p> <p>Expressed as a percentage</p> <p>Reference Range:</p> <p>Female: 35 – 49%</p> <p>Male: 40 – 54%</p>

RBC, HGB, and HCT



RBC Indices

- Includes the following parameters:
 - Mean Cell Volume (MCV)
 - Mean Cell Hemoglobin (MCH)
 - Mean Cell Hemoglobin Concentration (MCHC)
- Provides information on the size and hemoglobin content of RBCs (Useful in classifying anemias)
- Calculated using the RBC, HGB, and HCT
- Correlate with peripheral blood smear findings

Calculating RBC Indices

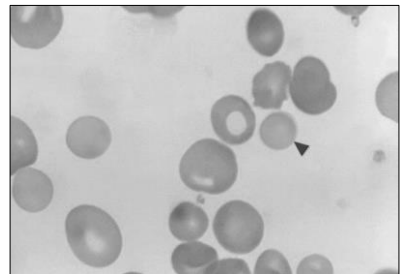
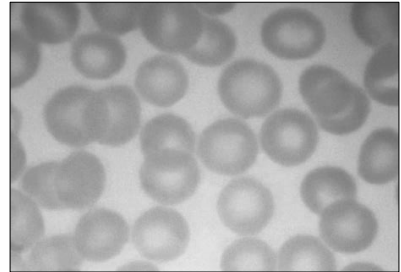
SIZE $MCV = \frac{HCT \times 10}{RBC}$ Reference Range: 80 – 100 fL

$MCH = \frac{HGB \times 10}{RBC}$ Reference Range: 28 – 32 pg

COLOR $MCHC = \frac{HGB \times 100}{HCT}$ Reference Range: 32 – 36 g/dL

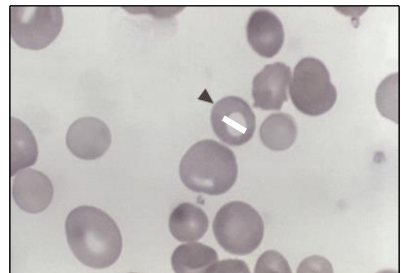
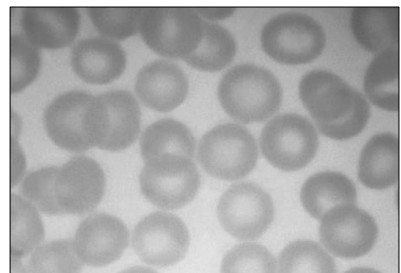
MCV < 80 fL

- Microcytes
 - Iron Deficiency Anemia (IDA)
 - Anemia of Chronic Disease (ACD)
 - Sideroblastic Anemia / Lead Poisoning
 - Thalassemia
 - Hgb E Disease and trait



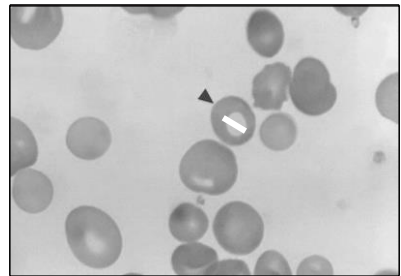
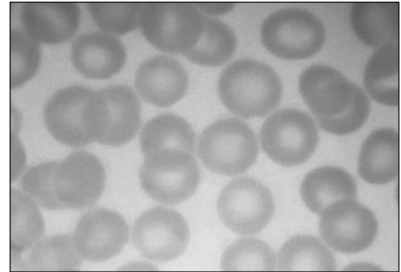
MCV > 100 fL

- Macrocytes
 - Vitamin B12 Deficiency
 - Folate Deficiency
 - Reticulocytosis
 - Chronic Liver Disease
 - Alcoholism
 - Aplastic Anemia



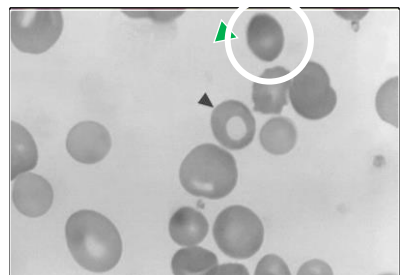
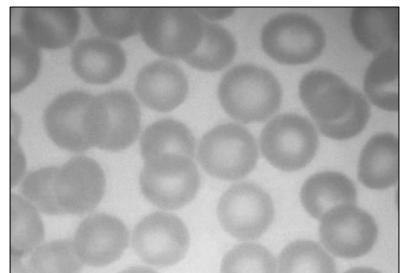
MCHC < 30 g/dL

- Hypochromia
 - Increased central pallor 1/3 cell diameter
 - Defective hemoglobin production
 - Related diseases/conditions
 - IDA
 - ACD
 - Thalassemia



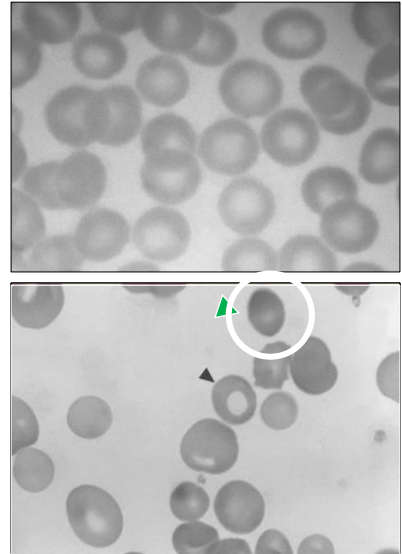
MCHC > 36 – 38 g/dL

- Hyperchromia
 - Hereditary Spherocytosis
 - Autoimmune hemolytic anemia
 - RBC agglutination



MCHC > 36 – 38 g/dL

- Hyperchromia
 - Hereditary Spherocytosis
 - Autoimmune hemolytic anemia
 - RBC agglutination
 - Hyperlipidemia – optical interference on automated analyzers



Normal MCV

- If anemia is present:
 - Hemolytic Anemia
 - Membrane Defects
 - Enzyme Deficiencies
 - Hemoglobinopathies
 - Chronic Kidney Disease
 - Immune and Non-immune causes

Red Blood Cell Distribution Width (RDW)

- Used to assess the variation in red blood cell size
- Reference Range: 11.5 – 14.5%
- ↑ RDW = Anisocytosis – increase variation in the size of RBCs
 - Examples:
 - Normocytes and Microcytes
 - Normocytes and Macrocytes
 - Normocytes, Microcytes, and Macrocytes
- Determined by evaluating the RBC histogram

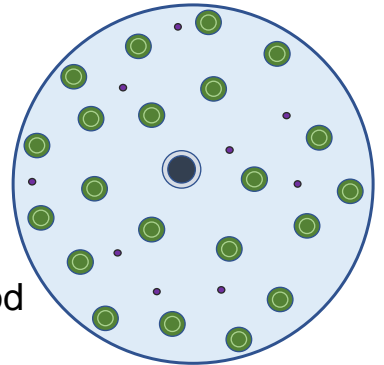
PLT Parameters

Platelet Count

Mean Platelet Volume (MPV)

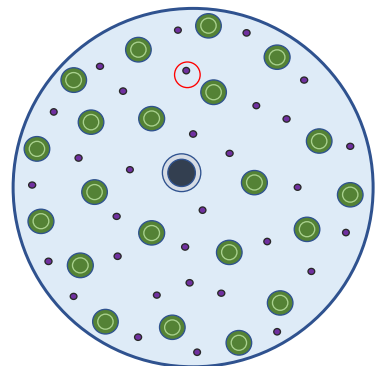
Platelet Count

- Thrombocytopenia, $PLT = < 150 \times 10^9 /L$
 - Decreased production in the bone marrow
 - Dehydration and Sepsis
 - Hematologic malignancies
 - Increased destruction in the peripheral blood
 - Microangiopathic anemias (i.e., Disseminated Intravascular Coagulation)
 - Lupus
 - Hypersplenism



Platelet Count

- Thrombocytosis, $PLT = > 450 \times 10^9 /L$
 - Hematologic malignancies
 - Essential Thrombocythemia (ET)
 - Infections or Inflammation
 - Post-splenectomy
 - Iron Deficiency Anemia



Mean Platelet Volume (MPV)

- Measures the average size of platelets
- Reference range: approximately 8 – 12 fL
 - Elevated MPV
 - Bone marrow compensation may result in giant platelets
 - Platelet consumption disorders (i.e., Idiopathic Thrombocytopenia)

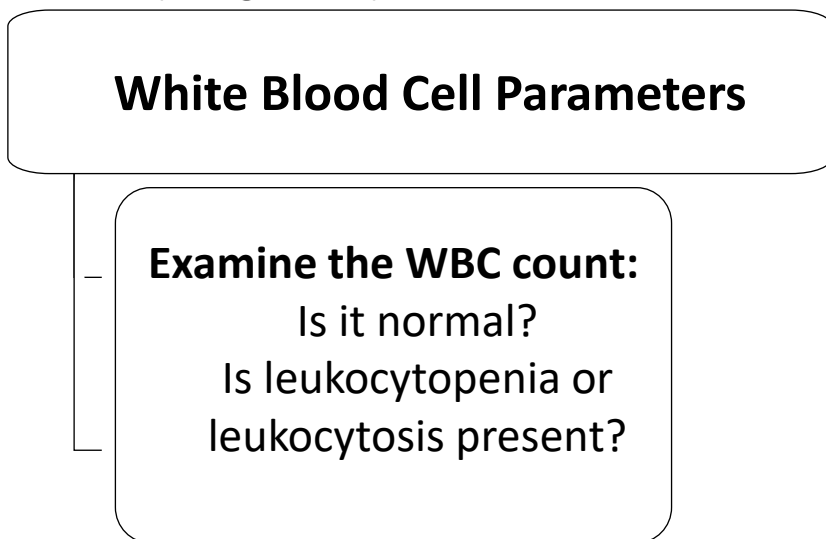
Interpreting CBCs

Let's Practice!

Applying a Systematic Approach

WBC Parameters	RBC Parameters	Platelet Parameters
<ul style="list-style-type: none">• Examine the WBC count:<ul style="list-style-type: none">• Is it normal?• Is leukocytopenia or leukocytosis present?	<ul style="list-style-type: none">• Examine the RBC, HGB, HCT<ul style="list-style-type: none">• Is anemia present?• Examine the RBC Indices<ul style="list-style-type: none">• Assess the cell size and Hgb concentration• Examine the RDW<ul style="list-style-type: none">• Is anisocytosis present?	<ul style="list-style-type: none">• Examine the PLT count:<ul style="list-style-type: none">• Is it normal?• Is thrombocytopenia or thrombocytosis present?• Examine the MPV<ul style="list-style-type: none">• Assess platelet size

Applying a Systematic Approach



Applying a Systematic Approach

Red Blood Cell Parameters

Examine the RBC, HGB, HCT

Is anemia present?

Examine the RBC Indices

Assess the cell size and Hgb concentration

Examine the RDW

Is anisocytosis present?

Applying a Systematic Approach

Platelet Parameters

Examine the PLT count:

Is it normal?

Is thrombocytopenia or thrombocytosis present?

Examine the MPV

Assess platelet size

CBC #1

Parameter	Result
WBC	6.7 x 10 ⁹ /L
RBC	2.91 x 10 ¹² /L
HGB	11.7 g/dL
HCT	34.8%
MCV	120 fL
MCH	40.2 pg
MCHC	33.6 g/dL
RDW	12.4%
PLT	185 x 10 ⁹ /L
MPV	10 fL

→ Normal
 } Anemia
 } Macrocytic,
 Normochromic
 → No anisocytosis
 } Normal

- Case History: 63-year-old male presenting with numbness and tingling of hands and feet and occasional shortness of breath.

Appropriate Follow-Up Tests:

Initial: Vitamin studies (Vitamin B₁₂ and Folate levels)
Secondary: Homocysteine and Methylmalonic acid (MMA)

Most likely diagnosis:

Vitamin B₁₂ deficiency

CBC #2

Parameter	Result
WBC	8.8 x 10 ⁹ /L
RBC	4.03 x 10 ¹² /L
HGB	6.8 g/dL
HCT	23.9%
MCV	59 fL
MCH	16.9 pg
MCHC	28.6 g/dL
RDW	19.8%
PLT	354 x 10 ⁹ /L
MPV	8.9 fL

→ Normal
 } Anemia
 } Microcytic,
 hypochromic
 → Anisocytosis
 } Normal

- 50-year-old female recently diagnosed with colon cancer complains of fatigue and shortness of breath.

Appropriate Follow-Up Tests:

Iron Studies:

- Serum iron levels
- Ferritin
- TIBC
- Transferrin

Most likely diagnosis:

Iron deficiency anemia

CBC #3

Parameter	Result
WBC	23.6 x 10 ⁹ /L
RBC	4.55 x 10 ¹² /L
HGB	14.7 g/dL
HCT	44.3%
MCV	97 fL
MCH	32 pg
MCHC	33 g/dL
RDW	14.3%
PLT	442 x 10 ⁹ /L
MPV	10 fL

→ Leukocytosis

} No anemia

} Normocytic, normochromic

→ No anisocytosis

} Normal

- 37-year-old male presents to the E.D. with a fever and a productive cough that brings up yellow phlegm.

Appropriate Follow-Up Tests:

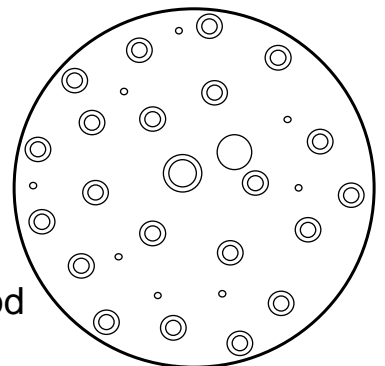
Sputum culture

Most likely diagnosis:

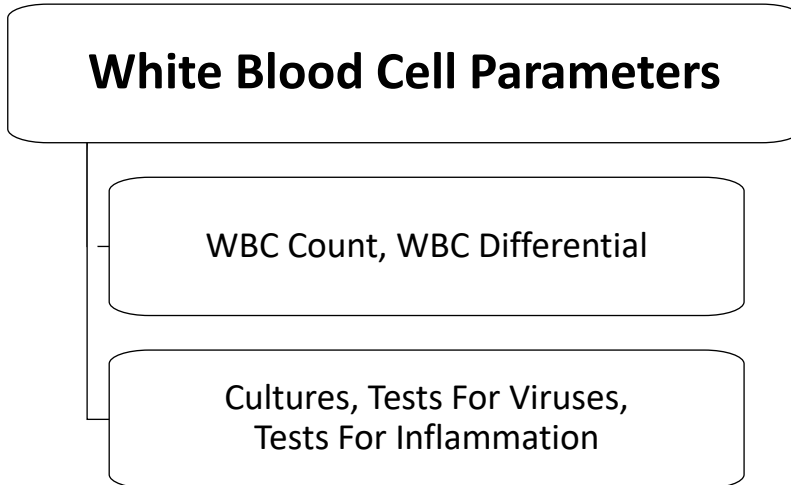
Bacterial infection (i.e., pneumonia)

Platelet Count

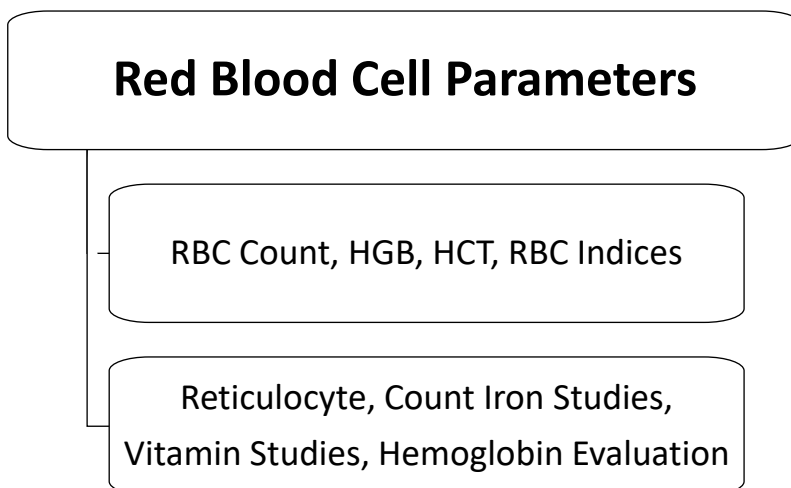
- Thrombocytopenia, PLT = < 150 x 10⁹ /L
 - Decreased production in the bone marrow
 - Dehydration and Sepsis
 - Hematologic malignancies
 - Increased destruction in the peripheral blood
 - Microangiopathic anemias
 - (i.e., Disseminated Intravascular Coagulation)
 - Lupus
 - Hypersplenism



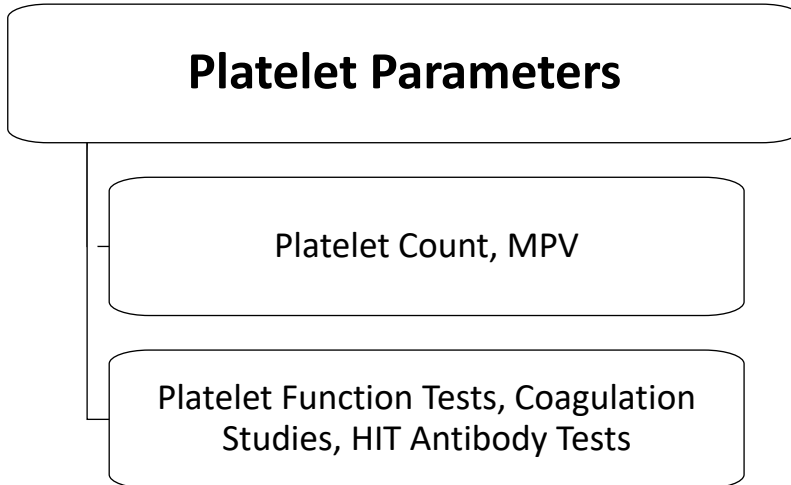
The Complete Blood Count (CBC)



The Complete Blood Count (CBC)



The Complete Blood Count (CBC)



Summary

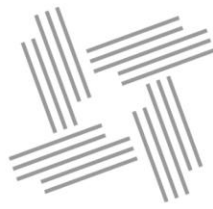
- The CBC provides valuable information to the physician that aids in patient diagnosis, treatment, and monitoring.
- Results from a CBC allow for the ordering of appropriate follow-up tests to further aid in patient diagnosis
- CBC interpretation should apply a systematic approach and in context with the patient's clinical presentation

Resources

- Doig, K., & Zhang, B. (2017) A methodical approach to interpreting the red blood cell parameters of the complete blood count. *ASCLS Clinical Laboratory Science Journal*, 30(3) 173-185. <https://doi.org/10.29074/ascls.30.3.173>
- Elsevier Patient Education. (2021, June 2). Complete Blood Count. <https://elsevier.health/en-US/preview/complete-blood-count>
- Jiang, F. (2021, September 28). The Meaning of Complete Blood Count (CBC) Abbreviations. *GoodRx Health*. <https://www.goodrx.com/health-topic/diagnostics/cbc-medical-abbreviations>
- Ahmed, M. M., Ghauri, S. K., Javaeed, A., Rafique, N., Hussain, W., & Khan, N. (2020). Trends of utilization of Complete Blood Count parameters for patient management among doctors in Azad Kashmir. *Pakistan Journal of Medical Sciences*, 36(5), 999–1004. <https://doi.org/10.12669/pjms.36.5.1885>

References

- Rodak's Hematology: Clinical Principles and Applications, 5th ed. (2019). Keohane, Smith, Walenga. Chapter 5, pgs. 42-64, Chapter 16 pgs. 235-25.
- Complete Blood Count (CBC). *Lab Tests Online*. Retrieved from: <https://labtestsonline.org/tests/complete-blood-count-cbc>
- SUCCESS! In *Clinical Laboratory Science*, 4th ed. (2009). Ciulla, A., Lehman, D. Chapter 2, pg. 283-284



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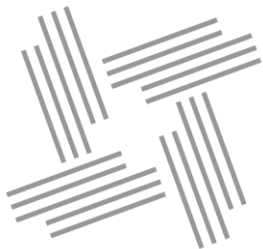
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