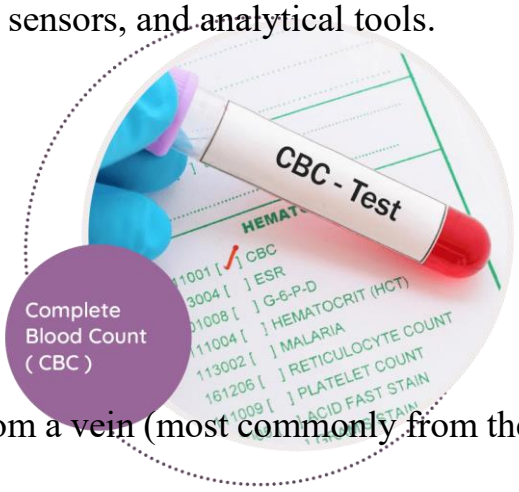
Blood Sample and Complete Blood Count (CBC) in Biomedical Engineering

In biomedical engineering, blood samples and the analysis of their components are fundamental for diagnosing diseases, developing medical devices, and understanding human health. The **Complete Blood Count (CBC)** is one of the most performed diagnostic tests that provide a wealth of information about the overall health of an individual and can indicate a variety of conditions.

I. Blood Sample in Biomedical Engineering

A **blood sample** is a specimen taken from the bloodstream for analysis. Blood is composed of several components, each of which has a specific role in the body's functions. Understanding these components is essential for biomedical engineers who work with diagnostic devices, sensors, and analytical tools.



A. Types of Blood Samples

1. **Venous Blood Samples**:
   - Typically collected from a vein (most commonly from the arm) using a needle.
   - Venous blood is the most common type used for diagnostic testing, including CBC, liver function tests, and cholesterol levels.
2. **Capillary Blood Samples**:
   - Often collected via a fingerstick or heel stick (for infants).
   - Used for smaller tests like glucose monitoring, rapid diagnostic tests, or when only a small amount of blood is needed.
3. **Arterial Blood Samples**:
   - Collected from an artery (usually the wrist or groin).
   - Provides information about the oxygenation and acid-base balance of the blood (e.g., used in arterial blood gas testing).

B. Blood Sample Collection Techniques

- **Needle Venipuncture**: A needle is inserted into a vein to draw blood. It's the most common and ideal method for collecting blood in large quantities for multiple tests.
- **Capillary Puncture (Fingerstick or Heelstick)**: A small incision is made in the skin to collect blood from small capillaries, typically used for point-of-care tests.
- **Arterial Puncture**: A more complex procedure where blood is drawn from an artery to assess oxygen levels, acid-base balance, or for some types of specialized tests.

II. Complete Blood Count (CBC)

A **Complete Blood Count (CBC)** is a comprehensive blood test used to evaluate overall health and detect a variety of disorders, including anemia, infection, and leukemia. It measures several components of blood, each providing critical insights into the body's physiological condition.

TEST REPORT

Patient	: MR. TRIJUGEE NARAYAN SHUKLA	**Reg. No.**	: 2108119998
Age / Gender	: 68 Y / Male	**Reg. Date**	: 27-Aug-2021
Ref. By	: DR. A. GUPTA, MBBS	**Report Date**	: 27-Aug-2021
Associate	: SRN DIAGNOSTICS INDORE	**Laboratory**	

COMPLETE BLOOD COUNT (CBC)

Parameter	Observed Value	Unit	Biological Reference Interval
Hemoglobin	**10.0**	**g/dL**	**13.0 - 17.0**
RBC Count	**3.66**	**million/cmm**	**4.6 - 6.2**
Hematrocrit	**30.1**	**%**	**40 - 54**
MCV	82.3	fL	80 - 96
MCH	27.3	Pg	27 - 33
MCHC	33.2	%	32 - 36
RDW- CV	13.7	%	11 - 16
RDW-SD	48.2	fL	35 - 56
PLATELET COUNT	**116**	**10^3/µL**	**150 - 410**
MPV	10.4	fL	6.5 - 12.0
PDW	26.3		25.0 - 65.0
PCT	**1.21**	**%**	**0.108 - 0.282**
TOTAL COUNT (WBC), EDTA blood	4.61	10^3/µL	4.0 - 10.0
DIFFERENTIAL WBC COUNT (Manual By Microscopy)			
Neutrophils (%)	**75**	**%**	**38 - 70**
Lymphocytes (%)	20	%	20 - 45
Monocytes (%)	03	%	2 - 8
Eosinophils (%)	02	%	1 - 4
Basophils (%)	00	%	0 - 1
Neutrophils (Abs)	3.64	10^3/µL	
Lymphocytes (Abs)	0.78	10^3/µL	
Monocytes (Abs)	0.16	10^3/µL	
Eosinophils (Abs)	0.00	10^3/µL	
Basophils (Abs)	0.03	/cmm	

Interpretation : The test is done on fully automated 5 PART cell counter of 'Mindray BC 5300'Specimen : WB-EDTA

---------- End of Report ----------

A. Components of a CBC

The CBC typically includes the following measurements:

1. **Red Blood Cell Count (RBC)**:
    - Measures the number of red blood cells in the blood, which carry oxygen from the lungs to the body and return carbon dioxide to the lungs for exhalation.
    - Abnormal RBC counts can indicate conditions like anemia (low RBC) or polycythemia (high RBC).
2. **White Blood Cell Count (WBC)**:
    - Measures the number of white blood cells, which are part of the immune system and help fight infection.
    - High WBC counts may indicate infection, inflammation, or an immune system disorder, while low WBC counts may suggest a weakened immune system or bone marrow problems.
3. **Hemoglobin (Hb)**:
    - Hemoglobin is a protein in red blood cells that carries oxygen. The CBC measures its concentration in the blood.
    - Low levels of hemoglobin can indicate anemia, while high levels may indicate dehydration or certain types of lung or heart diseases.
4. **Hematocrit (Hct)**:
    - Measures the proportion of blood that is made up of red blood cells.
    - Low hematocrit levels can suggest anemia, while high levels may indicate dehydration or certain types of polycythemia.
5. **Platelet Count (PLT)**:
    - Measures the number of platelets, which are responsible for blood clotting.
    - Low platelet counts may indicate a bleeding disorder, while high counts may increase the risk of clotting.
6. **Mean Corpuscular Volume (MCV)**:
    - Measures the average volume of red blood cells. This helps diagnose different types of anemia.

- Low MCV indicates microcytic anemia (smaller than normal red blood cells), while high MCV indicates macrocytic anemia (larger than normal red blood cells).

7. **Mean Corpuscular Hemoglobin (MCH)**:
   - Measures the average amount of hemoglobin per red blood cell.
   - Can help diagnose anemia and assess whether it is due to iron deficiency or other factors.
8. **Mean Corpuscular Hemoglobin Concentration (MCHC)**:
   - Measures the average concentration of hemoglobin in a given volume of red blood cells.
   - It helps to identify types of anemia and assess red blood cell characteristics.
9. **Red Cell Distribution Width (RDW)**:
   - Measures the variation in the size of red blood cells. Higher RDW values can indicate a variety of conditions, including different types of anemia or blood disorders.

III. Applications of CBC in Biomedical Engineering

In biomedical engineering, the analysis of blood components plays an important role in the development and testing of diagnostic tools, medical devices, and in the overall monitoring of patient health.

A. Diagnostic Device Development

1. **Point-of-Care Devices**: Biomedical engineers develop portable devices that can quickly analyze a blood sample and provide CBC results. These devices are useful in emergency settings, remote areas, or for home monitoring.
2. **Automated Blood Analyzers**: High-throughput machines, known as hematology analyzers, are used in clinical laboratories to perform CBC tests efficiently and accurately. Engineers work on improving the precision, speed, and cost-effectiveness of these devices.
3. **Wearable Sensors**: Research in biomedical engineering is leading to wearable sensors that can monitor blood composition, including red and white blood cell counts, hemoglobin levels, and platelet count in real-time, providing continuous health monitoring.

B. Disease Detection and Monitoring

- **Anemia**: Engineers work on devices that can detect low hemoglobin levels or RBC count, providing early warnings for conditions like anemia.
- **Infection and Inflammation**: Elevated WBC counts are often a sign of infection or inflammation. Biomedical engineers develop systems that can detect such changes and alert healthcare professionals to intervene early.
- **Leukemia and Other Blood Disorders**: CBC is essential for diagnosing leukemia and monitoring the progression of blood cancers. Devices that can automatically detect irregular blood cell counts or shapes are critical in cancer diagnosis and management.

C. Drug Development

- **Pharmacokinetics and Toxicity Testing**: Biomedical engineers work on systems that simulate blood composition to test the effects of drugs on various blood parameters, ensuring drug safety and efficacy before clinical trials.

IV. Preparing Blood Samples for CBC Testing

A. Blood Sample Handling

1. **Anticoagulants**: Blood samples for CBC are typically collected in tubes with anticoagulants (e.g., EDTA) to prevent clotting, ensuring that the blood remains in a liquid state for accurate testing.
2. **Sample Storage**: Blood samples should be processed promptly to avoid degradation of blood components. Samples that cannot be processed immediately are stored under refrigerated conditions.
3. **Sample Processing**: Once collected, the sample may be analyzed using a **hematology analyzer**, which counts and classifies blood cells, measures hemoglobin levels, and computes the various CBC parameters.

B. Quality Control and Calibration

- Regular quality control tests are performed on blood analyzers to ensure accuracy. Engineers ensure the calibration of machines to avoid false readings and to ensure consistency across different testing locations.