

Routine Lab Tests: Normal and Abnormal

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- Laboratory tests are among the most important aspects of modern medicine given that a large percentage of health care decisions, from diagnosis through therapy and prognosis, are derived from clinical laboratory tests.
- The quality of a test result is only as good as the quality of the specimen analyzed.

Arterial blood gases and Venous blood gases

- Except for pH, oxygen, carbon dioxide and bicarbonate, other laboratory results (glucose, enzymes, lipids, etc) are the same in arterial and venous blood.
- Blood gas studies are usually performed to:
 - Assess respiratory diseases and other lung conditions
 - Assess oxygen pressure in blood for therapeutic reasons
 - Assess acid-base status

Specimen collection

- Blood is collected from an arterial puncture or an arterial line
 - Presence of air bubbles may increase oxygen values and lower carbon dioxide values
 - If patient is receiving oxygen, the oxygen concentration must remain the same for 20 minutes before the test
 - If the test is to be taken without oxygen, the gas must be turned off for 20 minutes before collection
- Mix by inversion for 20 to 30 sec
 - Excess heparin (>0.1 ml per 1 ml of blood) may increase the acidity because of its high hydrogen ion concentration
- Immediately transport to laboratory on ice to reduce cellular metabolism

Normal values

- Partial pressure of Oxygen (PaO₂):75-100 mm Hg
- Partial pressure of Carbon dioxide (PaCO₂): 35-45 mm Hg
- Oxygen content (O₂CT):15-23%
- Oxygen saturation (SaO₂):94-100 %
- Bicarbonate (HCO₃): 22-26 mEq/L
- pH:7.35-7.45

- Values outside the Normal Range may indicate respiratory or metabolic (kidney) disease
 - Keep in mind that we are evaluating the patient's respiratory status, not just his oxygen;
 - We are evaluating the patient's acid-base balance, not his pH.
- Patients suffering from trauma affecting breathing, especially head and neck injuries, may have abnormal results
- Disorders, such as anemia, that affect the oxygen-carrying capacity of blood, can produce an abnormally low oxygen content

HEMATOLOGY TESTS

- Many conditions result in increases or decreases of blood cell populations
- Complete Blood Count (CBC) is a panel of tests that provides information about white blood cells, red blood cells, and platelets
 - It involves determining the numbers, concentrations, and conditions of the different types of blood cells
- Results can be used to diagnose or monitor treatment

Complete Blood Count (CBC)

Normal Values

- White Blood Cell Count (WBC)..... 5,000-10,000 μL
- Red Blood Cell Count (RBC)..... 4.7-6.1 million/ μL
- Hemoglobin..... 14-18 g/dL
- Hematocrit.....42-52%
- Red Blood Cell Indices
 - Mean Corpuscular Volume (MCV)..... 80-90 fL
 - Mean Corpuscular Hemoglobin (MCH) 27-31 pg
 - Mean Corpuscular Hemoglobin Concentration..... 32-36%
 - Red Blood Cell Distribution (RDW)..... 11-14.5%
- Platelet Count150,000-450,000 μL

- **White blood cell count (WBC)** is a count of the actual number of white blood cells per volume of blood.
 - WBC protect the body against infection and aid in the immune response
 - If there is an infection, white blood cell numbers will increase, attack and destroy the bacteria, fungus, or virus causing the infection
 - Increased number of WBC are also seen in leukemias
 - Conditions or medications that weaken the immune system, such as HIV infection, chemotherapy, or radiation therapy cause a decrease in white blood cells.

- **Red blood cell (RBC)** count represents the actual number of red blood cells per volume of blood.
- RBC carry oxygen from the lungs to the cells of organs in the body and transport carbon dioxide from those cells back to the lungs.
- Changes in the RBC count are usually associated with changes in hemoglobin levels.
 - When the values of the RBC count and hemoglobin decrease below the established reference range, the patient is said to be anemic.
 - When the values increase above this range, the patient is said to be polycythemic.

- **Hemoglobin** measures the amount of oxygen-carrying protein in the blood.
- Hemoglobin rises when the number of RBC increases.
- Hemoglobin falls to less than normal, indicating anemia, in conditions that lead to
 - decreased production of RBC
 - increased destruction of RBC
 - blood loss
- Hemoglobin levels help make decisions about blood transfusions if the anemia is severe

- **Hematocrit** measures the percentage of red blood cells in a given volume of whole blood.
 - It reflects both the number of red cells and their volume (MCV).
 - If the size of the red cell decreases, so will the hematocrit and vice versa.
- Hematocrit increases when
 - RBC production increases
 - Plasma volume is reduced, as in dehydration.
- It falls to less than normal, indicating anemia, when
 - RBC production decreases
 - Increased RBC destruction
 - Blood is lost due to bleeding

- **Mean corpuscular volume (MCV)** is a measurement of the average size of your RBCs.
- **Mean corpuscular hemoglobin (MCH)** is a calculation of the average amount of oxygen-carrying hemoglobin inside a red blood cell.
- **Mean corpuscular hemoglobin concentration (MCHC)** is a calculation of the average concentration of hemoglobin inside a red cell.

- **The platelet count** is the number of platelets in a given volume of blood.
- Both increases and decreases can point to abnormal conditions of excess bleeding or clotting.
- Platelets are the first components to be activated when there has been an injury to a blood vessel or tissue.
 - Because they are very "sticky," they begin the formation of a blood clot.

Coagulation Test

- Partial Thromboplastin Time (PTT).....26-36 sec
- Prothrombin Time (PT).....10-13 sec
- International Normalized Ratio.....2-3
- Fibrinogen.....190-390 mg/dl
- Antithrombin III (AT₃).....76-136%
- Fibrin Split Product.....Negative
- D-dimer test.....Negative

Partial Thromboplastin Time (PTT)

- The PTT test results are used to investigate a bleeding or thrombotic episode, to monitor unfractionated (standard) heparin therapy, and/or as part of a pre-surgical screen testing.
- Pre-analytical problems of prolonged PTT may include:
 - Insufficient sample- The anticoagulant to blood ratio must be 9:1 in the collection tube.
 - Heparin contamination- Most common problem, especially when blood is collected from intravenous lines that are being kept “open” with heparin washes.
 - Clotted blood samples- Depletion of coagulation factors

Prothrombin Time (PT)

- PT together with the International Normalized Ratio (INR) are used to monitor the effectiveness of anticoagulants such as warfarin (Coumadin).
 - Coumadin is prescribed on a long-term basis to patients who have experienced recurrent inappropriate blood clotting. This includes those who have had heart attacks, strokes, and deep vein thrombosis (DVT)

Fibrinogen (Factor I)

- Fibrinogen may be ordered as a follow-up to an abnormal PT or PTT and/or an episode of prolonged or unexplained bleeding.
- Reduced concentrations of fibrinogen may impair the body's ability to form a stable blood clot.
- Chronically low levels may be related to decreased production due to an inherited condition
- Acutely low levels are often related to consumption of fibrinogen such as may be seen with DIC and abnormal fibrinolysis.

Antithrombin III (AT3)

- AT3 activity testing is ordered, along with other tests, for hypercoagulation disorders
- AT3 may be ordered when a patient is not responding to heparin therapy as expected.
- Increased levels of antithrombin are not usually considered a problem
- Temporarily or chronically decreased AT3 levels may be seen with conditions that affect its consumption or production, such as:
 - DIC, DVT, Liver disease, Nephrotic syndrome, Pulmonary embolism, estrogen therapy

FDP & D-dimer

- The fragments of the disintegrating clot are called fibrin degradation products (FDP).
- One of the FDPs produced is D-dimer, which consists of variously sized pieces of crosslinked fibrin.
- D-dimer is normally undetectable in the blood and is produced only after a clot has formed and is in the process of being broken down.

- D-dimer tests are ordered, along with other laboratory tests and imaging scans, to help rule out, diagnose, and monitor diseases and conditions that cause hypercoagulability
- D-dimer may also be ordered, along with other tests, to help diagnose Disseminated Intravascular Coagulation (DIC).
- A positive D-dimer indicates the presence of an abnormally high level of fibrin degradation products.
 - It indicates significant clot (thrombus) formation and breakdown in the body.

Chemistry

- Glucose.....70-105 mg/dl
- Magnesium.....1.2-2.0 mEq/L
- Calcium..... 9.0-10.5 mg/dl
 - Ionized Calcium.....4.5-5.6 mg/dl
- Sodium..... 136-145 mEq/L
- Potassium..... 3.5-5.0 mEq/L

Glucose

- Glucose is a simple sugar that serves as the main source of energy for the body
- Most of the body's cells require glucose for energy production
 - Brain and nervous system cells not only rely on glucose for energy, they can only function when glucose levels in the blood remain above a certain level.
- The body's use of glucose depends on the availability of insulin, a hormone produced by the pancreas
- Specimen of choice is plasma collected on a gray top tube

Magnesium

- Magnesium is necessary for the formation and functioning of healthy bones, teeth, muscles, and nerves.
- It converts food into energy, builds proteins, and is instrumental in maintaining adequate levels of calcium in the blood.
- Magnesium helps prevent cardiovascular disease and irregular heartbeat, and increases an individual's chance of surviving a heart attack.
- It may also help prevent stroke and lessen the effects of existing osteoporosis.

- Since magnesium is an electrolyte, it may be ordered along with other electrolytes such as sodium, potassium, calcium, and phosphorus to evaluate a patient's electrolyte balance.
- If magnesium is low, it is not unusual for potassium to be low too.
- It also may be ordered in symptoms of abnormally low magnesium level such as muscle weakness, twitching, cramping, confusion, cardiac arrhythmias, and seizures.

Calcium

- The total calcium test is the test most frequently ordered to evaluate calcium status
- In some patients, the balance between bound and free calcium is disturbed, and total calcium is not a good reflection of calcium status.
- Conditions where ionized calcium should be the test of choice include
 - critically ill patients who are receiving transfusions or IV fluids
 - patients undergoing major surgery, and patients with blood protein abnormalities like low albumin.

Sodium

- Sodium makes possible proper nerve conduction, the passage of various nutrients into cells, and the maintenance of blood pressure.
- A blood sodium test may be ordered when a patient has symptoms of hyponatremia, such as weakness, confusion, and lethargy, or symptoms of hypernatremia such as thirst, decreased urinary output, muscle twitching, and/or agitation.
 - It may be ordered to determine if a disease or condition involving the brain, lungs, liver, heart, kidney, thyroid, or adrenal glands is causing or being exacerbated by a sodium deficiency or excess.

Potassium

- Potassium, a necessary electrolyte, facilitates nerve impulse conduction and the contraction of skeletal and smooth muscles, including the heart.
 - It also facilitates cell membrane function and proper enzyme activity.
- Because potassium is so important to heart function, it is usually ordered (along with other electrolytes) during all complete routine evaluations, especially in those who take diuretics, blood pressure or heart medications.
- Potassium levels can be falsely elevated in hemolyzed specimens.

References

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