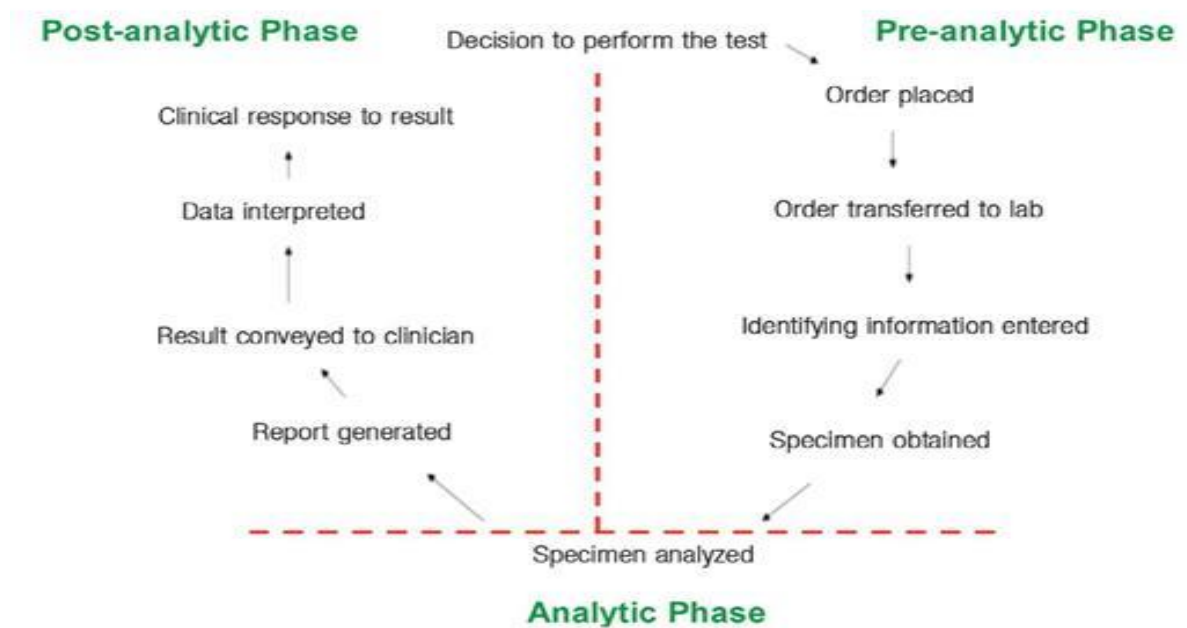


## Clinical laboratory tests used in the evaluation of disease states - significance and interpretation of test results

### The “Laboratory Testing Cycle”



### Significance and interpretation of Haematological test:

Hematology (*hema-* is from the Greek word for 'blood') is the study of blood in regards to a person's health or disease. It includes blood, blood-forming organs, and the proteins involved in bleeding and clotting.

Hematological tests can evaluate numerous conditions involving blood and its components. They can also be used to diagnose inflammation, anemia, infection, hemophilia, blood-clotting disorders, leukemia, and response to chemotherapy, among many other things. Let's take a look at some of these tests.

A **hematology test** is a blood test. Any test that requires blood or blood parts is a hematology test. These tests can offer information to a doctor about what is happening in the blood. The most common hematology tests include:

- Complete blood count (CBC) - This test counts the number of white blood cells, red blood cells, platelets, and more. This test helps to diagnose anemia, some blood cancers, inflammatory diseases, infections, and other health concerns.
- A **complete blood count (CBC)** measures several components and features of your blood. A CBC and its individual components are tested on whole blood. It can include measurements of the following:
  - Platelet count - This test is included in a CBC, but can also be done on its own in order to monitor clotting or bleeding disorders.
  - Prothrombin time or Partial Thromboplastin Time - These tests evaluate some blood disorders and monitor ongoing therapies.

- International Normalized Ratio - This test monitors anticoagulation as well as blood disorders, including anemia
- Hematology tests help to diagnose blood cancers, anemia, and disorders related to clotting, bleeding, and coagulation.

1. **White blood cells (WBC)**

make up the body's primary defense system, and knowing their number is an important tool in diagnosing and monitoring infection and leukemic disorders.

A normal WBC level is 4,500 - 11,000 per mm<sup>3</sup> of blood.

Increased WBC levels are most notably found in those with any type of infection, but are also found in anemia, collagen disorders, and those with physiologic stress, such as pregnancy.

Low WBC levels are seen in malnutrition, rheumatic disorders (like lupus, arthritis), some viral infections, and those undergoing chemotherapy or other forms of bone marrow suppression.

2. **Red Blood Cells:**

Red blood cells (RBC) are responsible for the transport and exchange of oxygen. Measurement of RBCs is important in monitoring the effects of blood loss and the progression of chronic disease. Normal counts of RBCs are 3,900,000 - 5,800,000 per mm<sup>3</sup> of blood.

RBC values are increased in those with anxiety or stress, bone marrow failure, and dehydration. A decreased RBC value will be found in those with chronic inflammatory diseases, chemotherapy patients, anemia, blood loss, and many cancers.

In addition to a count of WBCs and RBCs, a complete blood count can include further tests to evaluate the size, weight, and shape of those cells. These more detailed tests are helpful in diagnosing and monitoring therapy for cancer and anemic patients.

3. **Hematocrit and Platelets:**

**Hematocrit (HCT)** is the proportion of red blood cells to plasma, the fluid component of your blood. HCT helps to evaluate anemia and hydration. A normal percentage of hematocrit is 33 to 49%. The increase and decrease levels of HCT mirror those of hemoglobin. RBC, HgB, and HCT tests parallel each other and are frequently used together to evaluate anemia.

**Platelets (PLT)** have an essential function in blood clotting. A normal value is 150,000 - 450,000 platelets per mm<sup>3</sup> of blood. An increased platelet value is seen in conditions that involve inflammation, such as acute infection, trauma, and some malignant cancers. A decreased platelet count is found in alcohol toxicity, anemia, blood loss, infection, many congenial conditions, and coagulation disorders.

4. **Hemoglobin:**

**Hemoglobin (HgB)** is the oxygen-carrying protein in red blood cells. Hemoglobin levels are a direct reflection of the amount of oxygen in the blood. A normal hemoglobin concentration is 11-15 grams per deciliter of blood.

Increased HgB is seen in those with dehydration, chronic obstructive pulmonary disease, or COPD, and congestive heart failure, or CHF, and those at high altitude. A decreased HgB value is seen in anemia, blood loss, liver disease, as well as leukemia and lymphomas.

## LIVER FUNCTION TEST:

Liver function tests (also known as a liver panel) are blood tests that measure different enzymes, proteins, and other substances made by the liver. LFTs include liver enzymes, albumin and other proteins, and bilirubin. The liver enzymes are produced by cells within the liver. They include alkaline phosphatase (ALP),  $\gamma$ -glutamyl transpeptidase (GGT), alanine aminotransferase (ALT) and aspartate aminotransferase (AST), but the combination of liver enzyme results you receive depends on your local laboratory. The protein components comprise total protein, albumin and globulin [N.B. Total protein = Albumin + Globulins]. The globulins are a mixture of globular proteins such as immunoglobulins, enzymes, carrier proteins and complement. The LFT's reflect a limited range of hepatic metabolic processes. Bilirubin is an indication of the detoxification/excretory function and albumin reflects the synthetic function.

### Liver function tests are most often used to:

- Help diagnose liver diseases, such as hepatitis
- Monitor treatment of liver disease. These tests can show how well the treatment is working.
- Check how badly a liver has been damaged or scarred by disease, such as cirrhosis
- Monitor side effects of certain medicines

Need liver function testing if you have symptoms of liver disease. These include:

- Jaundice, a condition that causes your skin and eyes to turn yellow
- Nausea and vomiting
- Diarrhea
- Abdominal pain
- Dark-colored urine
- Light-colored stool
- Fatigue

Typical normal ranges for LFTs and other blood tests are shown in Table 1, but may vary according to your local laboratory.

Component	Abbreviation	Normal range
Bilirubin	Bili	<21 $\mu\text{mol/l}$
Alkaline phosphatase	ALP	30-130 IU/l
$\gamma$ -glutamyl transpedtidase	GGT	11-55 IU/l
Alanine aminotransferase	ALT	15-45 IU/l
Aspartate aminotransferase	AST	15-42 IU/l
Albumin	Alb	35-50 g/l
Globulin	Glob	20-40 g/l
Total protein	TP	60-80 g/l
Haemoglobin	Hb	135-185 g/l
Mean cell volume	MCV	78-100 fl
White cell count	WCC	4-11 $\times 10^9/l$

Platelets	Plts	140-400 x10 <sup>9</sup> /l
Prothrombin time	PT	9-12 s
International normalized ratio	INR	0.9-1.2
Urea	Urea	2.5-7.8 mg/dl
Creatinine	Creat	60-110 µmol/l

**Table 2. Chronic liver disease screen**

<b>Etiology</b>	<b>Investigation</b>
Biliary obstruction, tumours and frank cirrhosis	Abdominal US
Viral hepatitis	Hepatitis B and C serology
Autoimmune hepatitis	Liver autoimmune profile
Haemochromatosis	Ferritin
Hepatocellular carcinoma	α-fetoprotein
Wilson's disease	Caeruloplasmin
α <sub>1</sub> -antitrypsin deficiency	α <sub>1</sub> -antitrypsin

**Interpretation:**

Deranged LFTs are a common problem and their interpretation is complicated by the production of liver enzymes from multiple organs and the lack of specificity for markers of liver function. Therefore, it is important to interpret liver tests within the clinical context. Raised ALP reflects biliary tree injury and cholestasis, whereas raised AST and ALT levels usually reflect hepatocyte injury. Raised bilirubin and low albumin are the LFT components that can reflect impaired liver function, whilst raised PT or INR also provide a marker of liver synthetic function. A low platelet count may be seen in cirrhosis and signify the onset of portal hypertension.

**RENAL FUNCTION TEST :**

Renal function tests (RFT) are a group of tests that may be performed together to evaluate kidney (renal) function. The tests measure levels of various substances, including several minerals, electrolytes, proteins, and glucose (sugar), in the blood to determine the current health of the kidneys.

If the kidneys are not functioning properly, waste products can accumulate in the blood and fluid levels can increase to dangerous volumes, causing damage to the body or a potentially life-threatening situation. Numerous conditions and diseases can result in damage to the kidneys. The most common causes of and main risk factors for kidney disease are diabetes and hypertension.

Clinically, the most practical tests to assess renal function is to get an estimate of the glomerular filtration rate (GFR) and to check for proteinuria (albuminuria).

According to the Kidney Disease Improving Global Outcomes (KDIGO), The stages of chronic kidney disease (CKD):

- Stage 1 GFR greater than 90 ml/min/1.73 m<sup>2</sup>
- Stage 2 GFR-between 60 to 89 ml/min/1.73 m<sup>2</sup>
- Stage 3a GFR 45 to 59 ml/min/1.73 m<sup>2</sup>
- Stage 3b GFR 30 to 44 ml/min/1.73 m<sup>2</sup>
- Stage 4 GFR of 15 to 29 ml/min/1.73 m<sup>2</sup>
- Stage 5-GFR less than 15 ml/min/1.73 m<sup>2</sup> (end-stage renal disease)

#### **OTHERS:**

- Creatinine: Serum creatinine is elevated when there is a significant reduction in the glomerular filtration rate or when urine elimination is obstructed. About 50% of kidney function must be lost before a rise in serum creatinine can be detected. Thus serum creatinine is a late marker of acute kidney injury.
- BUN : Serum urea/BUN level increases in acute and chronic renal disease.
- eGFR equations are used to determine the presence of renal disease, stage of CKD, and to monitor response to treatment

#### **THYROID FUNCTION TEST:**

Thyroid function tests are blood tests which help to check the function of your thyroid gland. They are mainly used to detect an underactive thyroid gland (hypothyroidism) and an overactive thyroid gland (hyperthyroidism).

The two hormones, thyroxine (T4) and thyroid-stimulating hormone (TSH), work together and are usually in balance

#### **Normal range**

The following are approximate values for what is normal for TSH and thyroxine levels. These are a rough guide only and will vary from hospital to hospital.

- **Normal range for thyroid-stimulating hormone: 0.4-4.0 mU/L.**
- **Normal range for thyroxine: 9-24 pmol/L.**
- So in general if SH is low and thyroxine level is high, you may have an **overactive** thyroid gland.
- Conversely if TSH is high and thyroxine level is low, you may have an **underactive** thyroid gland.
- There are other options such as having a high TSH but a normal thyroxine and that can indicate something called subclinical hypothyroidism.

## TESTS ASSOCIATED WITH CARDIAC DISORDERS:

Many different tests are used to diagnose heart disease. Besides blood tests and a chest X-ray, tests to diagnose heart disease can include:

- **Electrocardiogram (ECG or EKG).** An ECG is a quick and painless test that records the electrical signals in the heart. It can tell if the heart is beating too fast or too slowly.
- **Holter monitoring.** A Holter monitor is a portable ECG device that's worn for a day or more to record the heart's activity during daily activities. This test can detect irregular heartbeats that aren't found during a regular ECG exam.
- **Echocardiogram.** This noninvasive exam uses sound waves to create detailed images of the heart in motion. It shows how blood moves through the heart and heart valves. An echocardiogram can help determine if a valve is narrowed or leaking.
- **Exercise tests or stress tests.** These tests often involve walking on a treadmill or riding a stationary bike while the heart is monitored. Exercise tests help reveal how the heart responds to physical activity and whether heart disease symptoms occur during exercise. If you can't exercise, you might be given medications.
- **Cardiac catheterization.** This test can show blockages in the heart arteries. A long, thin flexible tube (catheter) is inserted in a blood vessel, usually in the groin or wrist, and guided to the heart. Dye flows through the catheter to arteries in the heart. The dye helps the arteries show up more clearly on X-ray images taken during the test.
- **Heart (cardiac) CT scan.** In a cardiac CT scan, you lie on a table inside a doughnut-shaped machine. An X-ray tube inside the machine rotates around your body and collects images of your heart and chest.
- **Heart (cardiac) magnetic resonance imaging (MRI) scan.** A cardiac MRI uses a magnetic field and computer-generated radio waves to create detailed images of the heart.

## LUNG FUNCTION TESTS:

Lung function tests, also known as pulmonary function tests, or PFTs, are a group of tests that check to see if your lungs are working right. The tests look for:

- How much air your lungs can hold
- How well you move air in and out of your lungs

- How well the lungs move oxygen into your bloodstream. Your blood cells need oxygen to grow and stay healthy.

There are several types of lung function tests. They include:

- **Spirometry.** the most common type of lung function test. It measures how much and how quickly you can move air in and out of your lungs.
- **Lung volume test.** also known as body plethysmography. This test measures the amount of air you can hold in your lungs and the amount of air that remains after you exhale (breathe out) as much as you can.
- **Gas diffusion test.** This test measures how oxygen and other gases move from the lungs to the bloodstream.
- **Exercise stress test.** This test looks at how exercise affects lung function.

These tests may be used together or by themselves, depending on your specific symptoms or condition.

Other names: pulmonary function tests, PFTs

Lung function tests are often used to:

- Find the cause of [breathing problems](#)
- Diagnose and monitor chronic [lung diseases](#), including [asthma](#), chronic obstructive pulmonary disease ([COPD](#)), and [emphysema](#)
- See if lung disease treatments are working
- Check lung function before [surgery](#)
- Check whether exposure to chemicals or other substances in the home or workplace have caused lung damage

Below are the steps for the most common types of lung function tests.

**For a spirometry test:**

- You'll sit in a chair and a soft clip will be put on your nose. This is done so you'll breathe through your mouth, rather than your nose.
- You'll be given a mouthpiece that is attached to a machine called a spirometer.
- You'll place your lips tightly around the mouthpiece, and breathe in and out as instructed by your provider.
- The spirometer will measure the amount and rate of air flow over a period of time.

**For a lung volume (body plethysmography) test:**

- You'll sit in a clear, airtight room that looks like a telephone booth.
- As with a spirometry test, you'll wear a nose clip and place your lips around a mouthpiece connected to a machine.
- You'll breathe in and breathe out as instructed by your provider.
- The pressure changes inside the room help measure lung volume.

**For a gas diffusion test:**

- You'll wear a mouthpiece connected to a machine.

- You will be asked to inhale (breathe in) a very small, nondangerous amount of carbon monoxide or other type of gas.
- Measurements will either be taken as you breathe in or as you breathe out.
- The test can show how effective your lungs are in moving gases to your bloodstream.