



Lab Values and their Meanings

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Forward

The Laboratory Services are very pleased to see this report. Lab test are integral to patient care and depend on cooperation and support of ward staff for accurate and timely interpretation of the results.

This book should be of help to nursing in understanding some of the more common tests which are conducted.

Good lab results begin with proper collection of specimens and labeling. Nursing and ward staff can help by making sure proper directions are followed for specimen collection.

Proper labeling of specimens is paramount and great attention must be paid to labeling. Also of importance is the follow up of the results and appropriate action required based on the laboratory results.

Hopefully the information enclosed will be of value to all staff.

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Acknowledgement

The *LPN Lab Values Manual* was first compiled in response to a lack of information in the form of a quick reference manual for Licensed Practical Nurses in 2008. The Provision of safe, efficient and competent care was the catalyst to offer a quick resource tool that would assist nurses in their understanding of lab values and the effects on a patient's assessment and plan of care. This manual is a living document open to additions and revisions that will support care of Patients, Clients and Residents.

I would like to thank my LPN colleagues for their support in all of my work promoting best practice. Mary Van Osch, Clinical Nurse Educator, RCH Emergency conducted the original edition review. Dr. Adam Lund, BSc, MD, MDE, FRCPC (Emergency) Emergency Physician, Academic Director Royal Columbian & Eagle Ridge Hospitals, Clinical Associate Professor, Department of Emergency Medicine, UBC Adjunct Professor, School of Nursing, University of British Columbia, who graciously provided content review for 2008 & 2011 versions of this document.

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Thanks also to those not mentioned here who have contributed to making this project greater than I ever imagined.

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CHEMISTRY TESTS

Alanine Aminotransferase (ALT)

Normal Findings:

Elderly: may be slightly higher than adult values

Adult/child: **4 – 36 units/L (SI units)¹**

Indications:

This test is used to identify hepatocellular diseases of the liver. It is also an accurate monitor of improvement or worsening of these diseases.

Test Explanation:

ALT is found predominately in the liver; lesser quantities are found in the kidneys, heart, and skeletal muscle. Injury or disease affecting the liver functioning part of the organ (parenchyma) will cause a release of this hepatocellular enzyme into the bloodstream, thus elevating the ALT serum levels. Most ALT serum level increases are due to liver dysfunction. ALT serum levels are quite specific for hepatocellular disease indicators. In viral hepatitis the ALT/AST ratio is greater than 1, in hepatocellular disease the ratio is less than 1 u/L.

Test Results and Clinical Significance

Mildly Increased Levels:

- Myositis
- Pancreatitis
- Myocardial infarction
- Infectious mononucleosis
- Shock: *injury or disease affecting the liver, heart, or muscles will cause a release of this enzyme into the bloodstream.*

¹ Values may be higher in men and in African Americans

Moderately Increased Levels:

- Cirrhosis
- Hepatic tumor
- Cholestasis (obstructive jaundice)
- Hepatotoxic drugs
- Severe burns

Significantly increased levels:

- Hepatitis
- Hepatic necrosis
- Hepatic ischemia

Alkaline Phosphatase (ALP or ALK Phos)

Normal Findings:

Elderly: slightly higher than adult

Adult: **30 120 units/L**

Indications:

ALK Phos is used to detect and monitor diseases of the liver or bone.

Test Explanation:

Although ALK Ph. Is found in many tissues, the highest concentrations are found in the liver, biliary tract and bone. The intestinal mucosa and placenta also contain ALK Ph. The ALK Ph enzyme functions as an alkaline. It increases in an alkaline environment (pH of 9 -10). This enzyme test is important for detecting liver and bone disorders. This enzyme is excreted into the bile and increased levels can be indicators of extrahepatic and intrahepatic obstructive biliary disease and cirrhosis. Other liver abnormalities, such as hepatic tumors, hepatotoxic drugs, and hepatitis, cause smaller elevations. Evidence has indicated that the most sensitive test to indicate tumor metastasis to the liver is the ALK Ph test.

Bone is the most frequent extrahepatic source of ALK Ph.; new bone growth is associated with elevated levels. Diseases causing new bone growth due to osteoblastic metastatic tumors (ie: breast, prostate). Paget disease, healing fractures, rheumatoid arthritis, hyperparathyroidism, and normal-growing bones are all sources of elevated ALK Ph.

Interfering Factors:

- Recent ingestion of a meal can increase the ALK Ph level
- Age: young children with rapid bone growth. This is magnified during the growth spurt.
- Drugs that may cause increased ALK Ph levels (ie: albumin made from placental tissues, allopurinol, antibiotics, methyldopa, tetracycline)

Test Results and Clinical Significance

Increased Levels:

- Primary cirrhosis
- Intrahepatic or extrahepatic biliary obstruction
- Primary or metastatic liver tumor
- Normal pregnancy (third trimester, early postpartum period)
- Normal bones of growing children
- Metastatic tumor to the bone
- Healing fracture
- Hyperparathyroidism
- Paget disease
- Rheumatoid arthritis
- Intestinal ischemia or infarction
- Myocardial Infarction

Decreased Levels:

- Malnutrition
- Milk-alkali syndrome
- Pernicious anemia
- Scurvy (vitamin C deficiency)

Ammonia (or NH₃)

Normal Findings:

Adults: **15-60 micrograms per deciliter (mcg/dL) or**
 21-50 micromoles per liter (mcmol/L)

Indications:

Ammonia is used to support the diagnosis of severe liver diseases, and for surveillance of these diseases. Ammonia levels are also used in the diagnosis and follow-up of hepatic encephalopathy.

Test Explanation:

Ammonia is a by-product of the breakdown of protein. Most ammonia in the body forms when protein is broken down by bacteria in the intestinal tract. By way of the portal vein it goes to the liver, where it is normally converted into urea and then secreted by the kidneys. Impaired renal function diminishes excretion of ammonia and the blood levels rise. High levels of ammonia in the liver may be caused by diseases of the liver (Cirrhosis or severe hepatitis). Ammonia then crosses the blood/brain barrier and could result in encephalopathy or neurological dysfunction.

Interfering Factors:

- Hemolysis increases ammonia levels because the RBCs have about three times the ammonia level content of plasma.
- Muscular exertion can increase ammonia levels.
- Cigarette smoking can produce significant increases in ammonia levels within 1 hour of inhalation.
- Drugs that may cause **increased** ammonia levels include acetazolamide, alcohol, barbiturates, narcotics, parenteral nutrition and diuretics (loop, thiazide).

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- Drugs that may cause **decreased** ammonia levels include broad-spectrum antibiotics (neomycin), lactulose, levodopa, lactobacillus, and potassium salts.

Test Results and Clinical Significance

Increased Levels:

- Primary hepatocellular disease
- Reyes Syndrome
- Portal Hypertension
- Severe heart failure with congestive hepatomegaly:
The portal blood flow from the gut to the liver is altered. The ammonia cannot get to the liver to be metabolized for excretion. Furthermore the ammonia from the gut is rapidly shunted around the liver (by way of gastroesophageal varices) and into the systemic circulation.
- GI bleeding with mild liver disease
- GI obstruction with mild liver disease:
Ammonia production is increased because the bacteria have more protein (blood) to catabolize. An impaired liver may not be able to keep up with the increased load of ammonia presented to it.

Decreased Levels:

- Essential or malignant hypertension
- Hyperornithinemia

Amylase *cross reference "Lipase"*²

Normal Findings:

Adult: < 100 u/L

Indications:

This test is used to detect and monitor the clinical course of pancreatitis. It is frequently ordered when a patient presents with acute abdominal pain.

Test Explanation:

The serum amylase test, which is easy and rapidly performed, is most specific for pancreatitis. Amylase is normally secreted from pancreatic acinar cells into the pancreatic duct and then into the duodenum. Once in the intestine it aids in the breakdown of carbohydrates (starch) to their component simple sugars. Damage to pancreatic acinar cells (as in pancreatitis) or obstruction of the pancreatic duct flow (as in pancreatic carcinoma or common bile duct gallstones) causes an outpouring of this enzyme into the intrapancreatic lymph system and the free peritoneum.

Interfering Factors:

- IV dextrose solutions can lower amylase levels and cause a false-negative result.
- Drugs that may cause **increased** serum amylase levels include aminosalicylic acid, aspirin, azathioprine, corticosteroids, dexamethasone, ethyl alcohol, glucocorticoids, loop diuretics (eg: furosemide), methyldopa, narcotic analgesics, oral contraceptives and prednisone.
- Drugs that may cause **decreased** levels include citrates, glucose and oxalates.

² Lipase is becoming the preferred lab value depending on the physicians order for diagnostic purposes

Test Results and Clinical Significance

Increased Levels:

- Acute pancreatitis
- Chronic relapsing pancreatitis:
Damage to pancreatic acinar cells as in pancreatitis causes an outpouring of amylase into the intrapancreatic lymph system and the free peritoneum. Blood vessels draining the free peritoneum and absorbing the lymph pick up the excess amylase.
- Penetrating peptic ulcer into the pancreas:
The peptic ulcer penetrates the posterior wall of the duodenum into the pancreas. This causes a localized pancreatitis with elevated amylase levels.
- GI disease:
In patients with perforated peptic ulcer, necrotic bowel, perforated bowel, or duodenal obstruction, amylase leaks out of the gut and into the free peritoneal cavity.
- Acute cholecystitis
- Parotiditis (mumps)
- Renal failure
Amylase is cleared by the kidney. Renal diseases will reduce excretion of amylase.
- Diabetic Ketoacidosis
- Pulmonary infarction

Urea or (Blood Urea Nitrogen) Serum

Critical Values: indicates serious impairment of renal function

Normal Findings:

Adult: 2-9 mmol/L

Indications:

Urea (BUN) is an indirect and rough measurement of renal function and glomerular filtration rate (if normal liver function exists). It is also a measurement of liver function. It is performed on patients undergoing routine laboratory testing. It is usually performed as a part of a multiphase automated testing process.

Test Explanation:

The Urea measures the amount of urea nitrogen in the blood. Urea is formed in the liver as the end product of protein metabolism and digestion. During ingestion, protein is broken down into amino acids. In the liver these amino acids are broken down and free ammonia is formed. The ammonia molecules are combined to form urea, which is then deposited in the blood and transported to the kidneys for excretion. Therefore the Urea is directly related to the metabolic function of the liver and the excretory function of the kidney. It serves as an index of the function of these organs.

Nearly all renal diseases cause an inadequate excretion of urea, which causes the blood concentration to rise above normal. The Urea is interpreted in conjunction with the creatinine test. These tests are referred to as "**renal function studies**". The Urea is less accurate than creatinine as an indicator of renal disease.

Test Results and Clinical Significance

Increased Levels:

- Shock
- Burns
- Dehydration:

With reduced blood volume, renal blood flow is diminished. Therefore renal excretion of Urea is decreased and Urea levels rise.

- Congestive Heart Failure
- Myocardial Infarction

With reduced cardiac function, renal blood flow is diminished. Therefore renal excretion of urea is decreased and urea levels rise.

- GI bleeding
- Starvation

As protein is broken down to amino acids at an accelerated rate, urea is formed at a higher rate and urea accumulates.

- Sepsis

As sepsis increases in severity, renal blood flow and primary renal function are reduced due to hypoperfusion. Urea levels rise.

Decreased Levels:

- Liver failure:

Urea is made in the liver from urea. Reduced liver function is associated with reduced urea levels.

Brain Natriuretic Peptide (BNP)

Normal Findings:

BNP < 100 pg/mL

Indications:

Natriuretic peptides are used to identify and stratify patients with congestive heart failure³ (CHF).

Test Explanation:

Natriuretic peptides are neuroendocrine peptides that prevent the activity of the renin-angiotensin⁴ system. There are three major natriuretic peptides (NPs).

- ANP – is synthesized in the cardiac atrial muscle.
 - ❖ (Normal range: 22-77 pg/mL)
- BNP – the main source of BNP is the cardiac ventricle.
- C-type – is produced by the endothelial cells.

The cardiac peptides are continuously released by the heart muscle cells in low levels. The rate of release can be increased by a variety of physiological factors including hemodynamic load⁵ to regulate cardiac reload and afterload. BNP and ANP have been used in the pathophysiology of hypertension, CHF and atherosclerosis. Both BNP and ANP are released in response to atrial and ventricular stretch causing vasorelaxation, inhibition of aldosterone secretion from the adrenal gland and renin from the kidney, resulting in increasing the natriuresis and reduction in blood volume.

BNP correlates to the left ventricular pressures so is a good indicator for CHF. The increasing levels of BNP the more severe the CHF. This test is becoming increasingly used in urgent care

³ Congestive heart failure is a condition in which the heart can no longer pump enough blood to the rest of the body.

⁴ The **renin-angiotensin** system is a complex biologic system between the heart, brain, blood vessels, and kidneys that leads to the production of biologically active agents, including **angiotensin I** and **II** and aldosterone

⁵ **Hemodynamics**, meaning literally "blood movement" is the study of blood flow or the circulation

settings to aid in the differential diagnosis of shortness of breath (SOB).⁶ If the BNP is elevated, the SOB is related to CHF. If BNP levels are normal then SOB is pulmonary and not cardiac in nature. This is particularly useful in assessing patients with medical histories of both cardiac and chronic lung disease.

Interfering Factors

- BNP levels are generally higher in healthy women than healthy men
- BNP levels are higher in older patients

Test Results and Clinical Significance

Increased levels

- Congestive Heart Failure
- Myocardial infarction
- Systemic hypertension

⁶ Note: The range of normal is wide, and the range of test in true pathology is also wide. A VERY high value may be helpful, but most results are indeterminate. Dr. A. Lund

Chloride, blood (Cl)

Normal Findings:

Adult: **98-108 mmol/L**

Indications:

This test is performed as a part of multiphase testing for what is usually called “electrolytes”. By itself, this test does not provide much information. However, with interpretation of the other electrolytes, chloride can give an indication of acid-base balance and hydration status.

Test Explanation:

Chloride is the major extracellular anion. Its primary purpose is to maintain electrical neutrality, mostly as a salt with sodium. It follows sodium losses and accompanies sodium excesses in an attempt to maintain electrical neutrality. Because water moves with sodium and chloride, chloride also affects water balance. Finally, chloride also serves as a buffer to assist in acid-base balance. As carbon dioxide increases, bicarbonate must move from the intracellular space to the extracellular space. To maintain electrical neutrality, chloride will shift back into the cell.

Hypochloremia and hyperchloremia rarely occur alone and usually are part of parallel shifts in sodium or bicarbonate levels. Signs and symptoms of hypochloremia include hyperexcitability of the nervous system and muscles, shallow breathing, hypotension and tetany. Signs and symptoms of hyperchloremia include lethargy, weakness and deep breathing.

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Interfering Factors:

- Excessive infusions of saline solutions can result in increased chloride levels.
- Drugs that may cause **increased** serum chloride levels include androgens, chlorothiazide, cortisone preparations, estrogens, hydrochlorothiazide, methyldopa, and nonsteroidal anti-inflammatory.
- Drugs that may cause **decreased** levels include aldosterone, bicarbonates, corticosteroids, cortisone, hydrocortisone, loop diuretics, thiazide diuretics and triamterene.

Test Results and Clinical Significance

Increased Levels (Hyperchloremia):

- Dehydration
Chloride ions are more concentrated in the blood.
- Excessive infusion of normal saline solution
Intake of chloride exceeds output, and blood levels rise.
- Kidney dysfunction

Decreased Levels (Hypochloremia):

- Over-hydration
- Congestive heart failure
Chloride is retained with sodium retention but is diluted by excess total body water.
- Vomiting or prolonged gastric suction
- Chronic diarrhea
Chloride is high in the stomach and GI tract because of HCl acid produced in the stomach.
- Chronic respiratory acidosis
- Burns
Sodium and Chloride losses from massive burns can be great.

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Creatine Kinase (CK) *cross reference "Troponins"*

Normal Findings:

Adult: < 165 U/L

Indications:

This test is used to support the diagnosis of myocardial muscle injury (Infarction). It can also indicate neurologic or skeletal muscle diseases.⁷

Test Explanation:

CK is found predominantly in the heart muscle, skeletal muscle, and brain. Serum CK levels are elevated when these muscle or nerve cells are injured. CK levels can rise within 6 hours after damage. If damage is not persistent, the levels peak at 18 hours after injury and return to normal in 2 to 3 days. When the total CK level is elevated injury to or disease of the skeletal muscle is present. Examples of this include myopathies, vigorous exercise, multiple intramuscular (IM) injections, ETC, cardioversion, chronic alcoholism, or surgery. Because CK is made only in the skeletal muscle, the normal value of total CK varies according to a person's muscle mass. Large muscular people may normally have a CK level in the high range of normal. This is important because high normal CK levels in these patients can mask a MI.

CK is the main cardiac enzyme studied in patients with heart disease. Because its blood clearance and metabolism are well known, its frequent determination (on admission and at 12 hours & 24 hours) can accurately reflect timing, quantity, and resolution of a MI. New blood

⁷ Note: CK is now rarely used in the context of ruling out myocardial injury, in favour of the more sensitive and specific Troponin tests. However, CK remains an important test in evaluating myonecrosis from crush injuries, compartment syndromes, and rhabdomyolysis. Dr. A. Lund

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assays for cardiac markers have promised to rapidly and accurately detect acute MI in the emergency room.

Troponin.

Both Troponin T and Troponin I are specific to cardiac tissue and are released following an MI. Troponins will be discussed in more detail in a later section (see pg 34).

Timing of Commonly Used Cardiac Enzymes

Enzyme	Elevation begins	Peaks	Returns to Normal
Total CK	4-6 hours	24 hours	3-4 days
CK- MB	4 hours	18 hours	2 days
Troponin T	4-6 hours	10-24 hours	10 days
Troponin I	4-6 hours	10-24 hours	4 days

Interfering Factors:

- IM injections can cause elevated CK levels
- Strenuous exercise and recent surgery may cause increased levels
- Muscle mass is directly related to a patient's normal CK level
- Drugs that may cause **increased** levels include ampicillin, some anesthetics, anticoagulants, aspirin, dexamethasone (Decadron), furosemide (Lasix), captopril, alcohol, lovastatin, lithium, lidocaine, propranolol, and morphine.

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Test Results and Clinical Significance

Increased Levels of Total CK:

- Diseases or injury affecting the heart muscle, skeletal muscle, and brain

Increased Levels of CK-MB Isoenzyme:

- AMI
- Cardiac aneurysm surgery
- Cardiac defibrillation
- Myocarditis
- Ventricular arrhythmias
- Cardiac ischemia

Any disease or injury to the myocardium causes CK-MB to spill out of the damaged cells and into the bloodstream, producing elevated CK-MB isoenzyme levels.

Creatinine, Blood

Critical Values: indicates serious impairment in renal function

Normal Findings:

Adult: 45-110 umol/L

Indications:

Creatinine is as part of a complete renal function panel including Urea and the eGFR which will be calculated to assist in the diagnosis of impaired renal function.

Test Explanation:

This test measures the amount of creatinine in the blood. Creatinine is a catabolic product of creatine phosphate, which is used in skeletal muscle contraction. The daily production of creatine, and subsequently creatinine, depends on muscle mass, which fluctuates very little. Creatinine, as Urea is excreted entirely by the kidneys and therefore is directly proportional to renal excretory function. Thus, with normal renal excretory function, the serum creatinine level should remain constant and normal. Only renal disorders, such as glomerulonephritis, pyelonephritis, acute tubular necrosis, and urinary obstruction, will cause an abnormal elevation in creatinine. There are slight increases in creatinine levels after meals, especially after ingestion of large quantities of meat. The serum creatinine test, as with the Urea is used to diagnose impaired renal function. The creatinine level is interpreted in conjunction with Urea and GFR. These tests are referred to as **renal function studies**.

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Age Related Concerns:

The elderly normally have lower creatinine levels due to reduced muscle mass. This may potentially mask renal disease in patients of this age group.

Interfering Factors:

- A diet high in meat content can cause transient elevations of serum creatinine.
- Drugs that may **increase** creatinine values include aminoglycosides (ie: gentamicin), cimetidine, and other nephrotoxic drugs such as cephalosporins (ie: cefoxitin)

Test Results and Clinical Significance

Increased Levels:

Diseases affecting renal function include:

- Glomerulonephritis
- Pyelonephritis
- Acute tubular necrosis
- Urinary tract obstruction
- Reduced renal blood flow (ie: shock, dehydration, congestive heart failure, atherosclerosis)
- Diabetic nephropathy
- Nephritis

With these illnesses, renal function is impaired and creatinine levels rise.

- **Note:** Patients with impaired renal function (i.e. high urea, creatinine, or low eGFR) are at increased risk of total renal failure after CT with contrast.
- Reference the “Contrast Induced Nephropathy” order set

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D-dimer (Fibrin Degradation Product, FDP)

Normal Findings:

Adult: < 500 ug FEU/L

Indications:

A d-dimer test is a blood test that measures a substance released as a blood clot breaks up. D-dimer levels are often higher than normal in people who have a blood clot.

In current practice, the most common indication for this test would be to rule out Pulmonary Embolus⁸ (PE) or Deep Vein Thrombosis (DVT)⁹.

Test Explanation:

The fragment D-dimer assesses both thrombin and plasmin activity. D-dimer is a fibrin degradation fragment that is made through fibrinolysis. As plasmin acts on the fibrin polymer clot, FDP's and D-dimer are produced. D-dimer is a highly specific measurement of the amount of fibrin degradation that occurs. Normal plasma does not have detectable amounts of fragment D-dimer. Levels of D-dimer can also increase when a fibrin clot is lysed by thrombolytic therapy. Thrombotic problems such as deep-vein thrombosis, pulmonary embolism, can be part of the complex clinical assessment using the D-dimer levels.

⁸ A pulmonary embolism is a blockage in an artery in the lung. It is usually due to a blood clot that has traveled to the lung from another part of the body, usually the leg (DVT).

⁹ Deep vein thrombosis is a condition in which a blood clot (thrombus) forms in the deep veins of the legs, pelvis, or arms. These veins are located near the bones and are surrounded by muscle.

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Test Results and Clinical Significance

Increased Levels:

- Disseminated intravascular coagulation (DIC):

This is a serious bleeding disorder resulting from abnormally initiated and accelerated clotting. The ensuing depletion of clotting factors and platelets may lead to uncontrollable hemorrhage.

DIC is always caused by an underlying disease (e.g. Multiple organ failure, mass transfusions). The underlying disease must be treated for the DIC to resolve.

- Primary fibrinolysis
- Deep-vein thrombosis
- Pulmonary embolism
- Vasoocclusive crisis of sickle cell anemia
- Surgery:

These clinical situations are associated with varying degrees of clotting and fibrinolysis. D-dimer is produced by the action of plasmin on the fibrin polymer clot.

Digoxin Level

Therapeutic range:

Heart failure - **0.5-2.0 ng/ml**

Arrhythmia - **1.5-2.0 ng/ml**

Indications:

A digoxin test is used to monitor the concentration of the drug in the blood. The dose of digoxin prescribed may be adjusted depending on the level measured.

Test Explanation:

A doctor may order one or more digoxin tests when a person begins treatment to determine if the initial dosage is within therapeutic range and then order it at regular intervals to ensure that the therapeutic level is maintained. A digoxin test may also be used to determine if symptoms are due to an insufficient amount of the drug or due to **digoxin toxicity**¹⁰. Digoxin takes approximately one to two weeks to reach a steady level in the blood and in the target organ, the heart. Once the dosage level is determined, digoxin levels are monitored routinely, at a frequency determined by the doctor, to verify correct dosage and if any changes occur in drug source, dosage, or other medications taken at the same time.

Test Results and Clinical Significance

Digoxin is primarily cleared from your system by the kidneys. When someone has kidney problems, their doctor may want to monitor kidney function and blood potassium levels since kidney dysfunction and low levels of potassium can result in symptoms of digoxin toxicity.

¹⁰ **Digoxin toxicity** is a poisoning that occurs when excess doses of digoxin are consumed acutely or over an extended period.

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The test may be done when toxicity is suspected and the affected person has signs and symptoms such as:

- Dizziness
- Blurred vision or seeing yellow or green halos
- Vomiting
- Diarrhea
- Irregular heartbeat
- Difficulty breathing
- Fatigue
- Shortness of breath
- Swelling in the hands and feet (edema)
- Characteristic EKG changes include bradycardia¹¹ (the most frequent vital sign abnormality in toxicity), a prolonged PR interval

Changes in health status can affect levels of digoxin and its ability to control symptoms. Digoxin tests may be done and the dose adjusted if necessary when someone experiences a physiologic change that may affect blood levels and effectiveness of digoxin. This may be when someone develops, for example, kidney or thyroid problems, cancer, or stomach or intestinal illness.

¹¹ **Bradycardia** in the context of adult medicine, is the resting heart rate of under 60 beats per minute

Glomerular Filtration Rate (GFR)

Normal Range:

Adult: **90-120 ml/min**

Indications:

The GFR test is used to screen for and detect early kidney damage and to monitor kidney status. Glomerular filtration rate (GFR) is a calculation that determines how well the blood is filtered by the kidneys, which is one way to measure remaining kidney function. Glomerular filtration rate is usually calculated using a mathematical formula that compares a person's size, age, sex, and race to serum creatinine levels.

Test Explanation:

It is performed by ordering a creatinine test and calculating the eGFR. The creatinine test is ordered frequently as part of a routine Comprehensive Metabolic Panel (CMP) or Basic Metabolic Panel (BMP), or along with a Urea (or BUN) test whenever a doctor wants to evaluate the status of the kidneys. It is ordered to monitor those with known kidney disease and those with conditions such as diabetes and hypertension that may lead to kidney damage.

Test Results and Clinical Significance

The GFR is used to monitor or evaluate kidney function early warning signs of kidney disease may include:

- Swelling or puffiness, particularly around the eyes or in the face, wrists, abdomen, thighs, or ankles
- Urine that is foamy, bloody, or coffee-colored
- A decrease in the amount of urine
- Problems urinating, such as a burning feeling or abnormal discharge during urination, or a change in the frequency of urination, especially at night

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- Mid-back pain (flank), below the ribs, near where the kidneys are located
- High blood pressure (hypertension)

As kidney disease worsens, symptoms may include:

- Urinating more or less often
- Feeling itchy
- Tiredness, loss of concentration
- Loss of appetite, nausea and/or vomiting
- Swelling and/or numbness in hands and feet
- Darkened skin
- Muscle cramps

A person's GFR decreases with age and some illnesses. There is different equation that should be used to calculate the GFR for those under the age of 18.

A GFR test may not be as useful for those who differ from normal creatinine concentrations. This may include people who have significantly more muscle (such as a body builder) or less muscle (such as a muscle-wasting disease) than the norm, those who are extremely obese, malnourished, follow a strict vegetarian diet, ingest little protein, or who take creatine dietary supplements.

Important to note GFR equations are not valid for those who are 75 year of age or older because muscle mass normally decreases with age.

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Glucose, Blood (Blood Sugar, Fasting Blood Sugar, FBS)

Normal Findings:

Adult: 4.0 – 8.3 mmol/L

Elderly: Increase in normal range after age 50 years

Indications:

This test is a direct measurement of the blood glucose level. It is most commonly used in the evaluation of diabetic patients, septic patients or any patient with an altered level of consciousness. Blood glucose testing is a vital part of the data gathering process of patient comprehensive assessments (ie: blood pressure, pulse, respirations, temperature) to help assist with diagnosis.

Test Explanation:

Through multiple feedback mechanisms, glucose levels are primarily controlled by insulin and glucagons, though many other things can affect the glucose level in the blood. Glucagon¹² breaks glycogen down to glucose in the liver and glucose levels rise. Glucose levels are elevated after eating. Insulin, which is made in the beta cells of the pancreatic islets of Langerhans, is secreted. Insulin attaches to insulin receptors in muscle, liver and fatty cells in which it drives glucose into these target cells to be metabolized to glycogen, amino acids and fatty acids. Blood glucose levels diminish.

¹² **Glucagon**, a hormone secreted by the pancreas, raises blood glucose levels. Its effect is opposite that of insulin, which lowers blood glucose levels

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In general, true glucose elevations indicate diabetes mellitus (DM), however, there are many other possible causes of hyperglycemia¹³. Similarly, hypoglycemia¹⁴ has many causes. Fingertick blood glucose determinations are often performed before meals and at bedtime. Results are compared with a sliding-scale insulin chart ordered by the physician to provide coverage with subcutaneous regular insulin.

Interfering Factors:

- Many forms of stress (ie: trauma, general anesthesia, infection, burns, MI, can cause increased serum glucose levels).
- Caffeine may cause increased levels.
- Most IV fluids contain dextrose, which is quickly converted to glucose. Most patients receiving IV fluids will have increased glucose levels.
- Drugs that may cause increased levels include antidepressants (tricyclics), beta-adrenergic blocking agents, corticosteroids, IV dextrose infusion, diuretic, Epinephrine, estrogens, glucagons, lithium, phenothiazines, phenytoin, and salicylates (acute toxicity).

Test Results and Clinical Significance

Increased Levels (Hyperglycemia):

- Diabetes mellitus (DM)
This disease is defined by glucose intolerance.
- Acute stress response
Severe stress, including infection, burns and surgery stimulates catecholamine release. This in turn stimulates glucagon secretion which causes hyperglycemia.
- Chronic renal failure
Glucagon is metabolized by the kidney. With loss of kidney function, glucagon and glucose levels rise.
- Acute pancreatitis

¹³ See signs and symptoms at end of text

¹⁴ See signs and symptoms at end of text

As cells are injured during the inflammation process, the contents of the pancreatic cells (including glucagon) are spilled into the bloodstream. The glucagon causes hyperglycemia.

- Diuretic therapy

Certain diuretics cause hyperglycemia.

- Corticosteroid therapy

Cortisol causes hyperglycemia (response to stress and to sepsis).

Decreased Levels (Hypoglycemia):

- Insulin overdose

This is the most common cause of hypoglycemia. Insulin is administered at too high of a dose (especially in brittle diabetes) and glucose levels fall.

- Insulinoma

Insulin is autonomously produced without regard to biofeedback mechanisms.

- Hypothyroidism

Thyroid hormones affect glucose metabolism. With diminished levels of this hormone, glucose levels fall.

- Addison disease

Cortisol affects glucose metabolism. With diminished levels of this hormone glucose levels fall.

- Extensive liver disease

Most glucose metabolism occurs in the liver. With decreased liver function, glucose levels decrease.

- Starvation

With decreased carbohydrate ingestion, glucose levels diminish.

Signs and Symptoms:

Hyperglycemia

The following symptoms may be associated with acute or chronic hyperglycemia, with the first three composing the classic hyperglycemic triad:

- *Polyphagia - frequent hunger, especially pronounced hunger*
- *Polydipsia - frequent thirst, especially excessive thirst*
- *Polyuria - frequent urination*
- *Blurred vision*
- *Fatigue (sleepiness).*
- *Weight loss*
- *Poor wound healing (cuts, scrapes, etc.)*
- *Dry mouth*
- *Dry or itchy skin*
- *Tingling in feet or heels*
- *Erectile dysfunction*
- *Cardiac arrhythmia*
- *Stupor*
- *Coma*

Hypoglycaemia causes symptoms such as:

- hunger
- shakiness
- nervousness
- sweating
- dizziness or light-headedness
- sleepiness
- confusion
- difficulty speaking
- anxiety
- weakness

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Lactic Acid (Lactate)

Normal Findings:

Venous blood: 5-20 mg/dL or 0.6 – 2.2 mmol/L (SI units)

Indications:

This test is a measurement of the lactic acid in the tissues associated with shock or localized vascular occlusion. Lactic acid is produced when oxygen levels in the body drop, and the tissues switch from aerobic to anaerobic means of energy production. Lactic acidosis is when lactic acid builds up in the bloodstream faster than it can be removed.

Test Explanation:

When tissues have normal oxygenation to the tissues, glucose is metabolized to CO₂ and H₂O for energy. When the tissues experience oxygen deprivation or hypoxemia then the glucose is converted to lactate (lactic acid) instead of CO₂ and H₂O and lactic acid buildup occurs causing lactic acidosis (LA). Therefore, blood lactate is a fairly sensitive and reliable indicator of tissue hypoxia. The hypoxia may be caused by local tissue hypoxia such as tissue hypoxia (ie: extremity ischemia) or generalized tissue hypoxia such as exists in shock.

Test Results and Clinical Significance

Increased Levels:

- **Shock (total body state)**
- **Tissue Ischemia:** Anaerobic metabolism ¹⁵ occurs in hypoxemic organs and tissues. As a result, lactic acid is formed, causing increased blood levels.

¹⁵ Anaerobic describing a type of cellular respiration in which usually carbohydrates are never completely oxidized because molecular oxygen is not used.

- **Carbon monoxide poisoning:** Carbon monoxide binds hemoglobin more tightly than oxygen resulting in lack of oxygen available to tissues for normal aerobic metabolism – anaerobic metabolism occurs.
- **Severe Liver Disease**
- Diabetes mellitus¹⁶ (nonketotic): Lactic Acid levels rise in patients with poorly controlled diabetes most likely because of inefficient aerobic glucose metabolism, causing increased production of this lactic acid.

¹⁶ **Diabetes mellitus**, often simply referred to as **diabetes**, is a group of metabolic diseases in which a person has high blood sugar, either because the body does not produce enough insulin, or because cells do not respond to the insulin that is produced

- Type 1 diabetes: results from the body's failure to produce insulin, and presently requires the person to inject insulin. (Also referred to as *insulin-dependent* diabetes mellitus, *IDDM* for short, and *juvenile* diabetes.)
- Type 2 diabetes: results from insulin resistance, a condition in which cells fail to use insulin properly, sometimes combined with an absolute insulin deficiency. (Formerly referred to as *non-insulin-dependent* diabetes mellitus, *NIDDM* for short, and *adult-onset* diabetes.)

Lipase

Normal Findings:

0-160 units/L (Normal value ranges may vary slightly among different laboratories)

Indications:

This test is used in the evaluation of pancreatic disease. In acute pancreatitis, elevated lipase levels usually parallel blood amylase concentrations, although amylase levels tend to rise and fall a bit sooner than lipase levels.

Test Explanation:

Lipase is a protein (enzyme) released by the pancreas into the small intestine (duodenum). It helps the body absorb fat by breaking the fat (triglycerides) down into fatty acids. As with amylase, lipase appears in the bloodstream following damage to or disease affecting the pancreatic acinar¹⁷ cells. Lipase is excreted through the kidneys so it is now apparent that other conditions can be associated with elevated lipase levels. Therefore elevated lipase levels are often found in patients with renal failure, intestinal infarction or obstruction also can be associated with lipase elevation.

In acute pancreatitis, elevated lipase levels usually parallel serum amylase levels. The lipase levels usually rise slightly later than amylase levels (24 – 48 hours after onset of pancreatitis) and remain elevated in the blood stream for 5 to 7 days. Due to Lipase peaking later and remaining elevated longer than amylase the usage of serum lipase levels are deemed more useful in the late diagnosis of acute pancreatitis. Lipase levels are less useful in more chronic pancreatic diseases (if: chronic pancreatitis, pancreatic carcinoma).

¹⁷ An **acinus** (adjective: **acinar**, plural **acini**) refers to any cluster of cells that resembles a many-lobed cluster

Interfering Factors

- Drugs that may cause **increased** lipase levels include: codeine, meperidine, morphine, cholinergics, indomethacin, methacholine and bethanechol.
- Drugs that may cause **decreased** levels include: calcium ions

Test Results and Clinical Significance

Increased Levels:

- Pancreatic diseases (ie: acute pancreatitis, chronic relapsing pancreatitis, pancreatic cancer) Lipase exists in the pancreatic cell and is released into the bloodstream when disease or injury affects the pancreas.
- Biliary disease (ie: acute cholecystitis, cholangitis, extrahepatic duct obstruction) Although the pathophysiology of these observations is not well understood it is suspected that lipase exists inside the cells of the hepatobiliary system. Disease or injury of these tissues would cause the lipase to leak into the bloodstream and cause levels to be elevated.
- Renal failure: Lipase is excreted by the kidney. If excretion is poor, as in renal failure, lipase levels will rise.
- Intestinal diseases (ie: bowel obstruction, infarction) Lipase exists in the mucosal cells lining the bowel (mostly in the duodenum). Injury through obstruction or ischemia will cause the cells to lyse¹⁸. Lipase will leak into bloodstream and cause levels to be elevated.
- Salivary gland inflammation or tumor: Like amylase, salivary glands contain lipase, although to a much lesser degree. Tumors, inflammation, or obstruction of salivary ducts will cause the cells to lyse. Lipase will leak into the bloodstream and cause levels to be elevated.

¹⁸ To induce lysis, or to cause dissolution or destruction of a cell membrane with lysisin

Potassium, Blood (K)

Normal Findings:

Adult: **3.5 - 5.0 mmol/L**

Indications:

This test is routinely performed in most patients investigated for any type of serious illness. Furthermore, because this electrolyte is so important to cardiac function, it is a part of all complete routine evaluations, especially in patients who take diuretics or heart medications.

Test Explanation:

Potassium is the major cation within the cell. The intracellular potassium concentration is approximately 150 mEq/L, whereas the normal serum potassium concentration is approximately 4 mEq/L. This ratio is the most important determinant in maintaining membrane electrical potential, especially in neuromuscular tissue. Because the serum concentration of potassium is so small, minor changes in concentration have significant consequences. Potassium is excreted by the kidneys. Potassium is an important part of protein synthesis and maintenance of normal metabolic portion of acid-base balance in that the kidneys can shift potassium or hydrogen ions to maintain a physiologic pH.

Symptoms of **hyperkalemia** include irritability, nausea, vomiting, intestinal colic, and diarrhea. Signs of **hypokalemia** are related to a decrease in contractility of smooth, skeletal, and cardiac muscles, which results in weakness, paralysis, hyporeflexia¹⁹, ileuses, increased cardiac sensitivity to digoxin, cardiac arrhythmias. This electrolyte has profound effects on the heart rate and contractility.

¹⁹ **Hyporeflexia** is the condition of below normal or absent reflexes

The potassium level should be carefully followed in patients with uremia, Addison disease, and vomiting & diarrhea and in patients taking potassium-depleting diuretics or steroid therapy. Potassium must be closely monitored in patients taking digitalis-like drugs, because cardiac arrhythmias may be induced by hypokalemia and digoxin.

Interfering Factors:

- Drugs that may cause **increased** potassium levels include aminocaproic acid, antibiotics, antineoplastic drugs, captopril, epinephrine, heparin, histamine, lithium, mannitol, potassium-sparing diuretics, and potassium supplements.
- Drugs that may cause **decreased** levels include acetazolamide, aminosalicic acid, glucose infusions, carbenicillin, cisplatin, diuretics (potassium wasting), insulin, laxatives, lithium carbonate, penicillin G sodium (high doses), phenothiazines, salicylates (aspirin).

Test Results and Clinical Significance

Increased Levels (Hyperkalemia):

- Excessive dietary intake
- Excessive IV intake

Because the amount of potassium in the serum is so small, minimal but significant increases in potassium intake can cause elevations in the serum level.

- Acute or chronic renal failure

This is the most common cause of hyperkalemia. Potassium excretion is diminished and potassium levels rise.

- Crush injury to tissues

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- Infection

Potassium exists in high levels in the cell. With cellular injury and lysis, the potassium within the cell is released into the bloodstream.

- Dehydration

Potassium becomes more concentrated in dehydrated patients, and serum levels appear to be elevated. When the patient is dehydrated, potassium levels may, in fact, be reduced.

Decreased Levels (Hypokalemia):

- Deficient dietary intake
- Deficient IV intake

The kidneys cannot reabsorb potassium to compensate for the reduced potassium intake. Potassium levels decline.

- Trauma, surgery and burns

The body's response to trauma is mediated, in part by aldosterone, which increases potassium excretion.

- Gastrointestinal (GI) disorders (e.g. diarrhea, vomiting)

Excessive potassium is lost because of ongoing fluid and electrolyte losses as indicated above.

- Diuretics

These medications act to increase renal excretion of potassium. This is especially important for cardiac patients who take diuretics and digitalis preparations.

Hypokalemia can exacerbate the ectopy that digoxin may instigate.

- Alkalosis

To maintain physiologic pH during alkalosis, hydrogen ions are driven out of the cell and into the blood. To maintain electrical neutrality, potassium is driven into the cell. Potassium levels fall.

- Insulin administration

In patients with hyperglycemia, insulin is administered. Glucose and potassium are driven into the cell. Potassium levels drop.

- Ascites

These patients have a decreased renal blood flow from reduced intravascular volume that results from the collection of fluid. The reduced blood flow stimulates the secretion of aldosterone, which increases potassium excretion. Furthermore, these patients are often taking potassium-wasting diuretics.

Sodium, Blood (Na)

Normal Findings:

Adult: **135-145 mmol/L**

Indications:

This test is part of a routine laboratory evaluation of all patients. It is one of the tests automatically performed when “serum electrolytes” are requested. This test is used to evaluate and monitor fluid and electrolyte balance and therapy.

Test Explanation:

Sodium is the major cation in the extracellular space, in which there are serum levels of approximately 140 mEq/L. The concentration of sodium intracellular is only 5 mEq/L. Therefore sodium salts are the major determinants of extracellular osmolality. The sodium content in the blood is a result of a balance between dietary sodium intake and renal excretion. Non-renal (ie: sweat) sodium losses normally are minimal.

Physiologically, water and sodium are closely interrelated. As free body water is increased, serum sodium is diluted and the concentration may decrease. The kidney compensates by conserving sodium and excreting water. If free body water were to decrease, the serum sodium concentration would rise. The kidney would then respond by conserving free water.

The first symptom of **hyponatremia** is weakness. When sodium levels fall below normal levels, confusion and lethargy occur. In severe cases stupor and coma can occur. Symptoms of **hyponatremia** include dry mucous membranes, thirst, agitation, restlessness, hyperreflexia, mania and convulsions.

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Interfering Factors:

- Recent trauma, surgery or shock may cause increased levels because renal blood flow is decreased.
- Drugs that may cause **increased** levels include anabolic steroids, antibiotics, clonidine, corticosteroids, cough medicines, laxatives, estrogens and oral contraceptives.
- Drugs that may cause **decreased** levels include carbamazepine, diuretics, sodium-free IV fluids, angiotensin-converting enzyme (ACE) inhibitors, captopril, haloperidol, heparin, nonsteroidal anti-inflammatory drugs, tricyclic antidepressants and vasopressin.

Test Results and Clinical Significance

Increased Levels (Hypernatremia):

- Increased dietary intake

If sodium (usually in the form of salt) is ingested at high quantities without adequate free water, hypernatremia will occur.
- Excessive sodium in IV fluids

If intake of sodium exceeds that amount in a patient without ongoing losses or a prior sodium deficit, sodium levels can be expected to rise.
- Excessive Free Body Water Loss:
 - ♦ Gastrointestinal (GI) loss (without dehydration)

If free water is lost, residual sodium becomes more concentrated.
 - ♦ Excessive sweating

Although sweat does contain some sodium, most is free water. This causes the serum sodium to become more concentrated. If the water loss is replaced without any sodium, sodium dilution and hypernatremia can occur.
 - ♦ Extensive thermal burns

If the burn is extensive, serum and a great amount of free water are lost through the open wounds. Sodium becomes more concentrated.

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- ♦ Diabetes insipidus

The deficiency of ADH (antidiuretic hormone) and the inability of the kidney to respond to ADH cause large free water losses. Sodium becomes concentrated.

Decreased Levels (Hyponatremia):

- Deficient dietary intake

Sodium intestinal absorption is highly efficient. Salt deficiency is rare.

- Deficient sodium in IV fluids

If IV replacement therapy provides sodium at a level less than minimal physiologic losses or less than ongoing losses, residual sodium will become diluted.

- Increased Sodium Loss:

- ♦ Diarrhea, vomiting or nasogastric aspiration

Sodium in the GI contents is lost with the fluid. Hyponatremia is magnified if IV fluid replacement does not contain adequate amounts of sodium.

- ♦ Diuretic administration

Many diuretic works by inhibiting sodium reabsorption by the kidney. Sodium levels can diminish.

- ♦ Chronic renal insufficiency

The kidney loses its reabsorption capabilities. Large quantities of sodium are lost in the urine.

- Increased Free Body Water:

- ♦ Excessive oral water intake

Psychogenic polydipsia can dilute sodium.

- ♦ Hyperglycemia

Each 60 mg/100ml increase of glucose above normal decreases the sodium because the osmotic effect of the glucose pulls in free water from the extracellular space and dilutes sodium.

- ♦ Excessive IV water intake:
When IV therapy provides less sodium than maintenance and ongoing losses, sodium will be diluted. If sodium-free IV therapy is given to a patient who has a significant sodium deficit, sodium dilution will occur with rehydration.
- ♦ Congestive heart failure
- ♦ Peripheral edema
These conditions are associated with increased free water retention. Sodium is diluted.
- ♦ Ascites

Troponins (Cardiac Specific)

Normal Findings:

Adult: < 0.06 ug/L

Indications:

This test is performed on patients with chest pain to determine if the pain is caused by cardiac ischemia. It is a specific indicator of cardiac muscle injury. Troponin is a cardiac protein. It is a marker of myocardial injury. Except in cases of chronic renal failure, an elevated Troponin is a marker of cardiac injury.

Test Explanation:

Cardiac troponins are the biochemical markers for cardiac disease. This test is used to assist in the evaluation of patients with suspected acute coronary ischemic syndromes. In addition to improving the diagnosis of acute ischemic disorders, troponins are also valuable for early risk stratification in patients with unstable angina.

Troponins are proteins that exist in skeletal and cardiac muscle that regulate the calcium-dependent interaction of myosin with actin for the muscle contractile apparatus.

Because of their extraordinarily high specificity of myocardial cell injury, cardiac troponins are very helpful in the evaluation of patients with chest pain. Cardiac troponins become elevated sooner and remain elevated longer than CPK-MB (see Creatine Kinase pg). This expands the time window of opportunity for diagnosis and thrombolytic treatment of myocardial injury. Finally, Troponins are more sensitive to muscle injury than CPK-MB. This is most important in evaluating patients with chest pain.

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Cardiac troponins become elevated as early as 3 hours after myocardial injury. Levels of Trop's may remain elevated for 7 to 10 days after MI, and trop's levels may remain elevated for up to 10 to 14 days. However, if re-infarction is considered, troponins are not helpful because they could be elevated from the first ischemic event. Each cardiac monitor has its specific use depending on the time from onset of chest pain to the time of presentation to the hospital.

Interfering Factors:

Troponins T levels are falsely ***elevated*** in dialysis patients.

Test Results and Clinical Significance

Increased Levels:

- Myocardial injury
- Myocardial infarction

This myocardial intracellular protein becomes available to the bloodstream after myocardial cell death because of ischemia. Blood levels therefore rise. Normally, no troponins can be detected in the blood.

Hematology Tests

Complete Blood Cell Count & Differential, (CBC, Diff)

The CBC and differential count (diff) are a series of tests of the peripheral blood that provide a tremendous amount of information about the hematological system and many other organ systems. They are inexpensively, easily, and rapidly performed as a screening test. The CBC and diff helps the health professional evaluate symptoms (such as weakness, fatigue, or bruising) and diagnose conditions (such as anemia, infection and many other disorders).

A CBC test usually includes:

- **Red blood cell count:**

Normal findings: 4.30 - 5.90 X 12¹²/L

Red blood cells carry oxygen from the lungs to the rest of the body. They also carry carbon dioxide back to the lungs so it can be exhaled. If the RBC count is low (anemia), the body may not be getting the oxygen it needs. If the count is too high (a condition called polycythemia vera), there is a risk that the red blood cells will clump together and block tiny blood vessels (capillaries).

- **Hemoglobin:**

Normal findings: Male 135-180 g/L Female: 115-160 g/L

Hemoglobin is the major substance in a red blood cell. It carries oxygen and gives the blood cell its red color. The hemoglobin test measures the amount of hemoglobin in blood and is a good indication of the blood's ability to carry oxygen throughout the body.

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- **Hematocrit or Packed Cell Volume (PCV):**

Normal findings: Male 0.41 - 0.52 Female 0.35- 0.47

The Hematocrit or Packed cell Volume represents the percentage of red blood cells as compared to the total blood volume. The test is usually ordered as part of the CBC and is used to diagnose and monitor anemia, dehydration and to check the severity of ongoing bleeding.

- **White Blood Cell Count:**

Normal findings: 4.0 – 11.0 X 10⁹/L

White blood cells protect the body against infection. If an infection develops, white blood cells attack and destroy the bacteria, virus, or other organism causing it. White blood cells are bigger than red blood cells and normally fewer in number. When a person has a bacterial infection, the number of white cells can increase dramatically. The number of white blood cells is sometimes used to identify an infection or monitor the body's response to cancer treatment. WBC can also be elevated in the context of trauma or major stress (anything that causes a major catecholamine release). In these cases, it is not a marker of infection.

- **White Blood Cell Types (WBC differential):**

Normal findings: Neutrophils:	2 - 8 X 10⁹/L
Lymphocytes:	1 – 4 X 10⁹/L
Monocytes:	0.1 – 0.8 X 10⁹/L
Eosinophils:	< 0.6 X 10⁹/L
Basophils:	< 0.2 X 10⁹/L

The WBC differential is of considerable importance because it is possible for the total WBC count to remain essentially normal despite a marked change in one type of leukocyte. The types of white blood cells include neutrophils, lymphocytes, monocytes, eosinophils, and basophils. Immature neutrophils, called band neutrophils, are also included and counted as part of this test. Each type of cell plays a different role in protecting the body. The numbers of each one of these types of white blood cells give

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important information about the immune system. An increase or decrease in the numbers of the different types of white blood cells can help identify infection, an allergic or toxic reaction to certain medications or chemicals, and many conditions, such as leukemia.

- **Platelet Count (Thrombocyte Count):**

Normal findings: 150 - 400 X 10⁹/L

Platelets (thrombocytes) are the smallest type of blood cell. They play a major role in blood clotting. When bleeding occurs, the platelets swell, clump together, and form a sticky plug that helps stop the bleeding. If there are too few platelets, uncontrolled bleeding may be a problem. If there are too many platelets, there is a risk of a blood clot forming in a blood vessel. Also, platelets may be involved in hardening of the arteries (atherosclerosis).

Why It Is Done?

A complete blood count may be done to:

- Evaluate the cause of certain symptoms such as fatigue, weakness, fever, bruising, or weight loss
- Detect anemia
- Determine the severity of blood loss
- Diagnose polycythemia vera
- Diagnose an infection
- Diagnose diseases of the blood, such as leukemia
- Monitor the response to some types of drug or radiation treatment
- Evaluate abnormal bleeding
- Screen for abnormal values before surgery

A complete blood count may be done as part of a routine physical examination. A blood count can provide valuable information about the general state of your health.

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Age-Related Concerns:

The WBC values tend to be age related. It is not uncommon for the elderly to fail to respond to infection by the absence of Leukocytes. The elderly may not develop an increased WBC count even in the presence of a severe bacterial infection.

Test Results and Clinical Significance

Increased Levels:

Red blood cell (RBC):

- Conditions that increase RBC values include smoking, exposure to carbon monoxide, long-term lung disease, kidney disease, certain forms of heart disease, alcoholism, liver disease, or a rare disorder of the bone marrow (polycythemia vera).
- Conditions that affect the body's water content can increase RBC values. These conditions include dehydration, diarrhea or vomiting, excessive sweating, severe burns, and the use of diuretics.

White blood cell (WBC):

- Conditions that increase WBC values include infection, inflammation, damage to body tissues (such as a heart attack), severe physical or emotional stress (such as a major trauma, fever, injury, or surgery), burns, kidney failure, lupus, tuberculosis (TB), rheumatoid arthritis, malnutrition, leukemia, and diseases such as cancer.
- The use of corticosteroids, under active adrenal glands, thyroid gland problems, or removal of the spleen can increase WBC values.

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Decreased Levels:

Red blood cell (RBC):

- Anemia reduces RBC values. Anemia can be caused by severe menstrual bleeding, stomach ulcers, colon cancer, inflammatory bowel disease, tumors, Addison's disease, thalassemia, lead poisoning, sickle cell disease, or reactions to some chemicals and medications.
- A lack of folic acid or vitamin B₁₂ can also cause anemia, such as pernicious anemia.

White blood cell (WBC):

- Conditions that can decrease WBC values include chemotherapy, aplastic anemia, viral infections, malaria, alcoholism, AIDS, lupus, or Cushing's syndrome.

Platelets:

- Low platelet values can occur in pregnancy or idiopathic thrombocytopenic purpura.

What Affects the Test?

Factors that can interfere with the test and the accuracy of the results include:

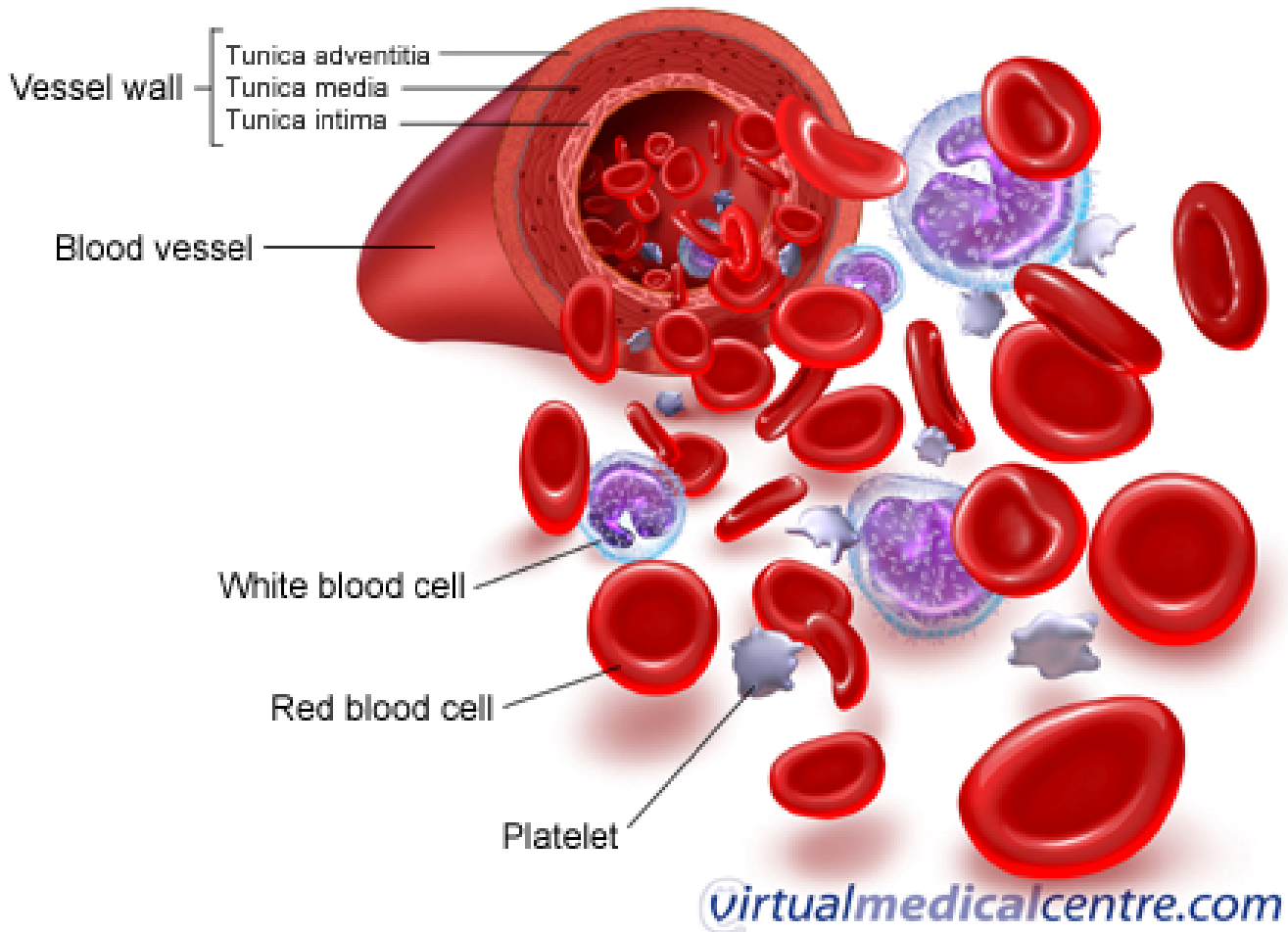
- Prolonged use of a tourniquet while drawing the blood sample.
- Medications that can cause low platelet levels. These include steroids, some antibiotics, thiazide diuretics, chemotherapy medications, and quinidine.
- A very high white blood cell count or high levels of a type of fat (triglycerides) that can cause falsely high hemoglobin values.
- An enlarged spleen, which may cause a low platelet count (thrombocytopenia). An enlarged spleen may be caused by certain types of cancer.
- Pregnancy, which normally causes a low value RBC value and an increase in WBCs.

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- Clumping of platelets in the test tube. This can result in a decreased platelet count and occurs because of the substance used in the test tube.



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Coagulation Tests

- **International Normalized Ratio (INR) and Prothrombin Time (PT)**
 - **Activated Partial Thromboplastin time (aPTT)**
-

International Normalized Ratio (INR) or Prothrombin Time (PT)

Normal Findings: (Please note: Normal values may vary from lab to lab)

INR: 0.8 – 1.12 (used at Fraser Health Authority)

PT: < 15 seconds

Indications:

Prothrombin time (PT) is a blood test that measures how long it takes blood to clot. A prothrombin time test can be used to screen for bleeding abnormalities. PT is also used to monitor treatment with medication that prevents the formation of blood clots.

A method of standardizing prothrombin time results, called the International Normalized Ratio (INR) system, has been developed to compare prothrombin time results among labs using different test methods. *Here at RCH we measure and report the prothrombin result as a ratio using the INR system.*

Test Explanation:

Prothrombin time (PT) is a blood test that measures how long it takes blood to clot. PT is used to monitor treatment with medication that prevents the formation of blood clots. The hemostasis and coagulation system is a balance between coagulation factors that encourage clotting and coagulation factors that encourage clot dissolution. The first reaction of the body to active bleeding is blood vessel constriction. In small vessel injury this may be enough to stop bleeding.

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In large vessel injury, hemostasis is required to form a clot that will plug the hole until healing can occur.

At least a dozen blood proteins, or blood clotting factors, are needed to clot blood and stop bleeding (coagulation). Prothrombin, or factor II, is one of several clotting factors produced by the liver. Adequate amounts of vitamin K are needed to produce prothrombin. Prothrombin time is an important coagulation test because it measures the presence and activity of five different blood clotting factors (factors I, II, V, VII, and X).

The prothrombin time is lengthened by:

- Low levels of blood proteins (blood clotting factors)
- A decrease in activity of any of the factors
- The absence of any of the factors
- The presence of a substance that blocks the activity of any of the factors

An abnormal prothrombin time is often caused by liver disease or injury or by treatment with the medication warfarin (coumadin), which is used to prevent the formation of blood clots.

The warfarin (coumadin) dosage for people being treated to prevent the formation of blood clots is usually adjusted so that the prothrombin time is about 1.5 to 2.5 times the normal value (or INR values 2 to 3). Prothrombin times are also kept at higher levels for people with artificial heart valves, for the same reason.

Coumadin derivatives are slow acting, but their action may persist for 7 to 14 days after discontinuation of the drug. The action of a coumadin drug can be reversed in 12 to 24 hours by slow parenteral administration of vitamin K. The administration of plasma will even more rapidly reverse the coumadin effect. The action of coumadin drugs can be enhanced by drugs such as aspirin, quinidine, sulfa and indomethacin.

To provide uniform PT results for physician in different parts of the country and the world, the World Health Organization has recommended that PT results now include the use of the international normalized ration (INR) value. Using the INR system, treatment to prevent blood

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clots (anticoagulant therapy) remains consistent even if a person has the test done at different labs. In some situations, only the INR is reported and the PT is not reported.

Interfering Factors:

- Alcohol intake can prolong PT times. Alcohol diminishes liver function. Many factors are made in the liver. Lesser quantities of coagulation factors result in prolonged PT times.
- A diet high in fat or leafy vegetables may shorten PT times. Absorption of vitamin K is enhanced. Vitamin K-dependent factors are made at increased levels, thereby shortening PT times.
- Diarrhea or malabsorption syndromes can prolong PT times. Vitamin K is mal absorbed, and as a result, factors II, VII, IX, and X are not made.
- Because of drug interactions, instruct the patient not to take any medications unless specifically ordered by the physician.

Test Results and Clinical Significance

- **Increased Levels (Prolonged PT):**
 - ♦ Liver disease (egg: cirrhosis, hepatitis): Coagulation factors are made in the liver. With liver disease, synthesis is inadequate and the PT is increased.
 - ♦ Hereditary factor deficiency: A genetic defect causes a decrease in a coagulation factor the PT is increased. Factors II, V, VII, or X could be similarly affected.
 - ♦ Vitamin K deficiency: Vitamin K-dependent factors (II, VII, IX, X) are not made. The PT is increased.
 - ♦ Bile duct obstruction: Fat-soluble vitamins, including vitamin K are not absorbed.
 - ♦ Coumadin ingestion: Synthesis of the vitamin K-dependent coagulation factors is inhibited.
 - ♦ Massive blood transfusion: Coagulation is inhibited by the anticoagulant in the banked blood. Furthermore, with massive bleeding, the factors are diluted out by the “factor-poor” banked blood.

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Why It Is Done?

Prothrombin time (PT) is measured to:

- Determine a possible cause for abnormal bleeding or bruising.
- Monitor the effects of the medication warfarin (Coumadin), which is used to prevent blood clots. If the test is done for this purpose, it may be repeated daily at first and then less often when the correct medication dose is determined.
- Screen for deficiencies of certain blood clotting factors. The lack of some clotting factors can cause bleeding disorders similar to hemophilia.
- Screen for a vitamin K deficiency. Adequate amounts of vitamin K are needed to produce prothrombin.
- Monitor liver function. Prothrombin levels are monitored along with other tests (such as aspartate aminotransferase and alanine aminotransferase) to help evaluate liver function. For more information, see the medical tests Aspartate Aminotransferase (AST) and Alanine Aminotransferase (ALT).

Activated Partial Thromboplastin time (aPTT)

Normal Findings: (Please note: Normal values may vary from lab to lab)

aPTT: 24-35 seconds

Indications:

The activated partial thromboplastin time (aPTT) test is used to determine the most effective dosage of some medications, such as heparin, that prevent blood clots. If the test is done for this purpose, an aPTT may initially be repeated every few hours. When the correct dosage is found, the frequency of testing is decreased. Apart from detecting abnormalities in blood clotting, it is also used to monitor the treatment effects with heparin, a major anticoagulant. Partial thromboplastin time is often measured along with prothrombin time to evaluate bleeding abnormalities.

Test Explanation:

Blood is collected in a tube containing oxalate which halts coagulation by binding with calcium. In order to activate the intrinsic pathway, elements such as calcium are mixed into the plasma sample. The time is measured until a thrombus (clot) forms. Values below 25 seconds and over 35 (depending on local normal ranges) are generally abnormal. Shortening of the PTT has little clinical relevance.

Prolonged aPTT may indicate:

- Use of heparin (or contamination of the sample)
- Antiphospholipid antibody (especially lupus anticoagulant, which paradoxically increases propensity to thrombosis)
- Coagulation factor deficiency (e.g. hemophilia)

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The heparin dosage for people being treated to prevent the formation of blood clots is usually adjusted so that the PTT or aPTT is about 1.5 to 2.5 times the normal value.

Abnormal Values:

- A longer-than-normal PTT or aPTT can indicate a deficiency or abnormality of one of the blood clotting factors or another substance needed to clot blood. A deficiency of one or more of these factors results in a bleeding disorder (such as hemophilia or von Willebrand's disease).
- A long PTT or aPTT can be caused by liver disease, kidney disease (such as nephrotic syndrome), or treatment with medications such as heparin or warfarin (Coumadin) that are used to prevent the formation of blood clots.
- A long PTT may be caused by conditions such as antiphospholipid antibody syndrome and lupus anticoagulant syndrome that can cause abnormal clotting or blood clot formation. These syndromes are a complication of lupus in which the immune system produces antibodies that attack certain blood clotting factors, causing the blood to clot easily in veins and arteries.
- PTT can be increased when aspirin is used during heparin therapy, so the PTT value needs to be closely monitored.

What Affects the Test?

Factors that can interfere with your test and the accuracy of the results include:

- Some herbal products or natural remedies
- Some medications, such as antihistamines

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URINE Tests

Urinalysis (UA)



Normal findings:

Appearance:	Clear
Color:	Amber yellow
Odor:	Aromatic
Leukocyte:	Negative
Nitrites:	None
Ketones:	None

Indications:

Urinalysis (UA) is part of routine diagnostic and screening evaluations. It can reveal a significant amount of preliminary information about the kidneys and other metabolic processes. UA is routinely done in all patients admitted to the hospital, pregnant women and pre-surgical patients. It is done diagnostically in patients with abdominal or back pain, dysuria, hematuria, or urinary frequency. It is part of routine monitoring in patients with chronic renal disease and some metabolic diseases. It is the most frequently ordered urine test.

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Laboratory Examination:

- Appearance and colour:

Appearance and colour are noted as part of routine urinalysis. A normal urine specimen should be clear. Cloudy urine may be caused by the presence of pus (necrotic WBC's), RBC's or bacteria. However, normal urine also may be cloudy because of ingestion of certain foods (ie: large amounts of fat, urates, phosphates). Urine ranges from pale yellow to amber because of the pigment urochrome (product of bilirubin metabolism). The color indicates the concentration of the urine. Dilute urine is straw colour and concentrated urine is deep amber.

- Odor:

Determination of urine odor is part of routine urinalysis. The aromatic odor of fresh, normal urine is caused by the presence of volatile acids. Urine of patients with diabetic ketoacidosis has the strong, sweet smell of acetone. In patients with a UTI, the urine may have a foul odor.

- Protein:

Protein is a sensitive indicator of kidney function. Normally protein is not present in the urine. If significant protein is noted at urinalysis, a 24-hour urine specimen should be collected so that the quantity of protein can be measured. This test can be repeated as a method of monitoring renal disease and its treatment.

- Leukocyte:

Leukocyte is a screening test used to detect leukocytes in the urine. Positive results indicate UTI. Some patients have no symptoms of UTI (ie: pain or burning on urination). Leukocyte esterase is nearly 90% accurate in detecting WBC's in urine.

- Nitrite:

Like the leukocyte esterase screen, the nitrite test is a screening test for identification of UTI's. This test is based on the principle that many bacteria produce an enzyme called reductase, which can reduce urinary nitrates to nitrites. Chemical testing is done with a dipstick containing a reagent that reacts with nitrites to produce a pink color, thus indirectly suggesting the presence of bacteria. A positive test result indicates the need for a urine culture. Nitrite screening enhances the sensitivity of the leukocyte esterase test to detect UTI's.

- Ketones:

Normally, no ketones are present in the urine. However a patient with poorly controlled diabetes and hyperglycemia may have massive fatty acid catabolism. The purpose of this catabolism is to provide an energy source when glucose cannot be transferred into the cell because of insulin insufficiency. Ketones are the end products of this fatty acid break down. As with glucose, ketones spill over into the urine when blood levels in diabetic patients are elevated. Ketonuria may occur with acute febrile illness, especially in infants and children.

Abbreviations for Common Laboratory Tests

ABG	Arterial Blood Gases
BUN	Blood Urea Nitrogen
Ca	Calcium
CK	Creatine Kinase
Cl	Chloride
CSF	Cerebrospinal fluid
Hb	Hemoglobin
INR	International normalization ratio
K	Potassium
LFT	Liver function tests
LP	Lumbar puncture
Mg	Magnesium
Na	Sodium
PT	Prothrombin Time
PTT	Partial Thromboplastin time
RBC	Red blood cell
Trop	Troponin
UA	Urinalysis
WBC	White blood cell

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