# Functional Medicine University's Functional Diagnostic Medicine Training Program

Module 1 \* Lesson 7

# **Blood Chemistry & CBC Analysis**

By Wayne L. Sodano, D.C., D.A.B.C.I., & Ron Grisanti, D.C., D.A.B.C.O., M.S. http://www.FunctionalMedicineUniversity.com

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# Blood tests are used to assess numerous disorders and body processes. They are performed for the following reasons:

- Assessment of nutritional status
- Screening for disease (PSA)
- To establish a diagnosis
- To monitor therapy (blood thinners, diabetes)
- To screen for toxins/drugs

#### **Reference Ranges**

Dr. Harry Eidenier, Jr., whose work is widely recognized and well respected in the area of balancing blood chemistry, stated to me "Blood chemistry, irrespective of range used (optimal or reference), is simply a tool to be used with other diagnostic criteria".

Dr. Eidenier was generous enough to grant permission to reference his work throughout this lesson. His contribution, along with our research will provide you with valuable insight to balancing blood chemistry and understanding what the numbers really mean.

Conventional reference ranges generally cover 95% of 'healthy' population, and does not account for a range of signs and symptoms related to a subclinical or physiological problem. These ranges are derived by assaying specimens from individuals who meet criteria for 'good' health (e.g., 'have no known health problems, are ambulatory, not on any medications and have a normal BMI)

There is also a significant amount of biological variability with reference ranges. An example of this is serum iron, which is higher in the morning and can drop by as much as 50% if the specimen is obtained at 2 p.m.

It is recommended that all follow up blood testing be taken at the same time of day as the original test.

#### Other variables include:

- Pregnancy
- Exercise
- Tourniquets (increase potassium and lactate and decreases pH)
- Circadian rhythms
- Medications

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#### **The History of Optimal Ranges**

The history of optimal ranges dates back to the 1980's. Dr. Eidenier explained to me that a method called the 'Biochemical Biopsy' was originally used in an attempt to look for changes in blood composition to detect cancer. The methods used for analysis were electrophoresis, atomic spectroscopy, hormonal studies, and standard hematological studies. This information was integrated with information form physical exams, symptom analysis, urinalysis, hair mineral analysis, stool analysis, and other diagnostic criteria. Over 10,000 people were studies, and this information is now used as what is referred to as the 'optimal ranges'.

Integrating the optimal ranges with a patient's history and physical exam allow us to use blood testing in a more preventive and functional manner.

#### **Functional Medicine University Initial Blood Test Panel**

- Complete Blood Count with Differential
- Comprehensive Metabolic Panel
- Lipid Panel
- Iron Panel
- TSH
- Total T4
- Total T3
- Uric Acid
- GGT
- Cardio CRP
- Hemoglobin A1c
- Vitamin D 25-Hydroxy
- eGFR

#### Functional Medicine University's Blood Test Result Tracking Form

This form is available at <a href="www.FunctionalMedicineUniversity.com">www.FunctionalMedicineUniversity.com</a> on line library. A copy of it is included at the end of your insiders' guide. Using this form will allow you to look at all of the positive test results and integrate them into the patient's history and physical exam to form a working diagnosis. It may also be used in decision making for advanced diagnostic testing.

• Note: It is extremely important that you are registered with CLIA (Clinical Laboratory Improvement Amendments) before you begin to perform in-office testing. A 1998 Amendment expanded earlier regulations to include all laboratories, regardless of size or location (including physician office laboratories) that test human specimens. This means that all laboratory testing, with the exception of waived tests (e.g., urine dipstick) are inspected for compliance with CLIA regulations by the Center for Medicare and Medicaid Services (CMS) or another agency recognized by CMS. To check for your state compliance regulations go to: <a href="www.cms.hhs.gov">www.cms.hhs.gov</a>.

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#### Complete Blood Count with Differential

#### White blood count

Leukocytes (white blood cells) of the peripheral blood are divided into two groups, the granulocytes and the non-granulocytes. Cells in these categories are:

#### **Granulocytes:**

Polymorphonuclear Neutrophils (Segmented and Bands)

Eosinophils

Basophils

#### Non-Granulocytes:

Lymphocytes

Monocytes

The major function of WBC's is to fight infection, react against foreign bodies or tissues, and defend the body by phagocytosis.

#### Clinical Significance

#### Increased levels:

- Childhood Diseases (Measles, Mumps, Chicken-Pox, Rubella, Etc)
- Acute Viral or Bacterial Infection
- Steroid Use
- Thyroid Storm
- Intestinal parasites
- Some types of cancer
- Infectious mononucleosis
- Adrenal dysfunction

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#### White Blood Count (con't)

#### Decreased levels:

- Chronic viral or bacterial infection
- Autoimmune disorder
- Systemic Lupus Erythematosis
- Hepatitis
- Vitamin B12, Vitamin B6 and folic acid anemia
- Intestinal parasites (chronic)
- Rheumatoid arthritis
- Iron deficiency

#### Red Blood Count

Red blood cells are responsible for carrying oxygen from the lungs to body tissues and the transference of carbon dioxide from the tissues to the lungs. The shape of the red cell enables the maximum amount of hemoglobin to be used. This test determines the total number of erythrocytes found in a cubic millimeter of blood.

#### Clinical Significance

#### *Increased levels:*

- Polycythemia
- Respiratory distress (asthma/emphysema)
- High altitude

- Iron anemia
- Vitamin B12, Vitamin B6 and/or folic acid anemia
- Liver and renal dysfunction
- Some cancers
- Hemorrhage

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#### Hemoglobin

Hemoglobin (HGB) is the major component of the red blood cell (RBC) and functions in the transport of oxygen.

#### Clinical Significance

#### Increased levels

- Dehydration
- Emphysema
- Asthma
- Polycythemia

#### Decreased levels:

- Iron deficiency anemia
- Microscopic internal bleeding
- Digestive inflammation

#### **Hematocrit**

The packed cell volume (HCT) is the percentage of the total volume occupied by packed red blood cells (RBC) when a given volume of whole blood is centrifuged.

#### Clinical Significance

#### Increased levels:

- Dehydration
- Emphysema
- Asthma
- Polycythemia

- Iron deficiency anemia
- Microscopic internal bleeding
- Digestive inflammation

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#### MCV

The MCV indicates the volume in cubic microns occupied by an average single red blood cell. A MCV increase along with an increase or decrease in the MCH is a significant finding for vitamin B12, folic acid, iron, copper or vitamin B6 anemia. MCV and MCH should always be viewed together to ascertain a possible vitamin B6, vitamin B12 or folic acid anemia. The suspicion of vitamin B6, vitamin B12 or folic acid anemia should be confirmed with a serum or urinary methylmalonic acid and homocysteine.

#### Clinical Significance

#### Increased levels:

- Vitamin B12/Folic acid anemia
- Dehydration

#### Decreased levels:

- Iron anemia
- Microscopic internal bleeding

#### <u>MCH</u>

MCH indicates the weight of hemoglobin in a single red blood cell. MCH increase or decrease along with an increase or decrease in MCV is a significant finding for vitamin B12, folic acid, iron, copper and vitamin B6 anemia.

#### Clinical Significance

#### Increased levels:

Vitamin B12/Folic acid anemia

- Iron anemia
- Internal bleeding
- Toxic effects of lead, aluminum, cadmium, and other toxic metals
- Vitamin B6 anemia

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#### MCHC

MCHC indicates the average hemoglobin concentration per unit volume (100mL) of packed red blood cells.

#### Clinical Significance

#### Increased levels:

- Vitamin B12/Folic acid anemia
- Dehydration

#### Decreased levels:

- Internal bleeding
- Toxic effects of lead, aluminum, cadmium, and other toxic metals
- Vitamin B6 anemia

#### RDW

The RDW is an electronic measurement of anisocytosis (red cell variability). An RDW increase is primarily indicative of iron deficiency anemia; however, it can also be increased with vitamin B12 and/or folate anemia.

#### **Platelets**

Platelets are involved with the clotting of blood coagulation, vasoconstriction, and vascular integrity. Breaks in small vessels are occluded by adhesion and aggregation of platelets.

#### Clinical Significance

#### Increased levels:

- Rheumatoid arthritis
- Arteriosclerosis
- Some types of cancer
- Inflammatory arthritis
- Several types of anemia
- Polycythemia
- During pregnancy (slight increase)

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#### Platelets (con't)

#### Decreased levels:

- Idiopathic thrombocytopenia
- Blood loss
- Thrombocytopenia

#### Neutrophils

The chief function of the neutrophil is that of phagocytosis.

#### Clinical Significance

*Increased levels*:

Active viral or bacterial infection

#### Decreased levels:

Chronic viral or bacterial infections

#### **Lymphocytes**

Lymphocytes help to destroy the toxic products of protein metabolism. They migrate to areas of inflammation in both early and late stages of the inflammatory process.

#### Clinical Significance

#### Increased levels:

- Chronic viral and bacterial infections
- Viral infection (mumps, rubella, Mononucleosis)

- Active viral and bacterial infections
- Leukemia
- Immunodeficiency disease
- Lupus
- Prednisone

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#### Monocytes

Monos phagocytize some bacteria, particulate matter and protozoa. In the inflammatory process neutrophils predominate for about three days then they break up and the monocytes remain to phagocytize fragments of cells, etc. This is the reason you will often find an increase in the monocytes during the recovery phase of an infection.

#### Clinical Significance

Increased levels:

Viral infections (mononucleosis)

Important considerations with an increased monocyte percentage:

- Always rule out liver dysfunction with increased monocytes
- Increased monocytes indicate excessive tissue breakdown
- An increase in the monocytes with an increase in the basophils (above 1.0) and even a mild increase in the eosinophils (above 3.0) is reason to suspect intestinal parasites.
- The monocyte percentage will frequently increase with a decrease in the lymphocyte percentage with Hodgkin's disease and several other forms of cancer.

#### **Eosinophils**

Eosinophils have an important role in detoxification and the breakdown and removal of protein.

#### Clinical Significance

Increased levels:

- Intestinal parasites
- Food and environmental allergy/sensitivity
- Asthma
- Emphysema

#### Decreased levels:

 An eosinophil count at or below 1% or less is an uncommon finding and if present adrenal cortical hyperfunction should be ruled out.

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#### **Basophils**

During inflammation, basophils deliver heparin to the inflamed tissue to prevent clotting; therefore, basophils will almost be increased with tissue inflammation. Basophils also contain histamine and serotonin.

#### Clinical Significance

#### Increased levels

- Tissue inflammation
- Intestinal parasites
- Polycythemia

#### Decreased levels:

- Stress
- Acute allergic reactions
- Hyperthyroidism

#### Comprehensive Metabolic Panel

#### AST

#### Aspartate Amino Transferase

ASOT/AST is an enzyme found in high concentrations in the heart, liver, skeleton, muscles, kidneys, and pancreas. It is functionally similar to SGPT/ALT; however, it is not increased as much as SGPT/ALT in liver problems. AST reversibly transfers the amino group of aspartic acid to alpha-keloglutaric acid to form oxaloacetic acid and glutamic acid.

#### Clinical Significance

#### Increased levels:

- Heart disease
- Liver disease
- Musculoskeletal
- Congestive heart failure
- Acute pancreatitis

- Vitamin B6 anemia
- Renal disease

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#### ALT

#### Alanine Aminotransferase

SGPT/ALT is used to identify hepatocellular disease. It is functionally similar to SGOT/AST. Alt reversibly transfers the amino acid group Alanine to alpha-ketoglutamic acid to form pyruvic acid and glutamic acid.

#### Clinical Significance

#### Increased levels:

- Cirrhosis of the liver
- Acute and chronic liver necrosis
- Hepatitis/mononucleosis
- Epstein-Barr virus and cytomegalovirus
- Acetaminophen

#### Decreased levels:

Vitamin B6 anemia

#### Alkaline Phosphatase

ALP is a member of a family of zinc metalloprotein enzymes that function to split off a terminal phosphate group from an organic phosphate ester, therefore a decreased serum ALP is frequently associated with zinc deficiency. Alkaline phosphatase is located in several tissues. In addition to the liver, it is also in bone, intestine, kidney, and placenta. The ISO enzymes of alkaline phosphatase are helpful in determining the source of increased blood level.

#### Clinical Significance

#### Increased levels:

- Healing fracture
- Liver cancer
- Cirrhosis
- Normal pregnancy (third trimester)
- Impairment of bile flow
- Paget's disease of bone

- Biliary obstruction
- Zinc deficiency
- Vitamin C insufficiency

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#### Total Bilirubin

Bilirubin is the end product of hemoglobin breakdown by the spleen, liver kupfer cells and the bone marrow (RES). In the liver, the indirect bilirubin is combined with Glucuronic acid to form a water soluble compound, direct or conjugated bilirubin, which is secreted in the bile. Bilirubin is classified as:

Total Bilirubin – A combination of direct and indirect bilirubin Direct Bilirubin – post-hepatic, water-soluble (conjugated) Indirect Bilirubin – Pre-hepatic, water-insoluble (unconjugated)

#### Clinical Significance

Increased levels: Conjugated (direct) Bilirubin

- Gallstones (biliary obstruction)
- Liver metastasis
- Extrahepatic duct obstruction

Increased levels: Unconjugated (indirect) Bilirubin

- Gilbert syndrome (congenital enzyme deficiency interrupting conjugation of bilirubin)
- Hepatitis
- Cirrhosis
- Hemolyticanemia

Decreased levels: None significant

#### Total Protein

Total protein is the combination of albumin and total globulin; therefore the total protein value will be affected by the albumin and total globulin. It is possible to have a normal total protein with an abnormal total globulin or albumin.

#### Clinical Significance

*Increased levels:* 

- Digestive dysfunction
- Dehydration

- Protein malnutrition/Amino acid need
- Digestive inflammation (Leaky Gut Syndrome, Gastritis, Colitis, Ileitis, Crohn's Disease, IBS, Etc)

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#### Albumin

Albumin is produced almost entirely by the liver; therefore, liver function has a major influence on albumin production and serum albumin levels. It is also responsible for about 80 percent of the colloid-osmotic pressure between blood and tissue fluids and serves as the transport protein for many substances. When albumin is decreased, osmotic pressure is disturbed. Decreased albumin is always an indication of significant liver or immune dysfunction and in many cases; decreased albumin indicated frank or developing free radical pathology (neoplasm). When albumin is decreased and globulins are increased, chronic liver disease is generally suspected.

#### Clinical Significance

Increased levels:

Dehydration

Decreased levels:

- Liver/biliary dysfunction
- Neoplasm
- Protein malnutrition/amino acid need

#### **Globulin**

Total globulin is a combination of the alpha 1, alpha 2, beta and gamma fractions and most laboratories calculate the total serum globulin by subtracting the serum albumin from the total serum protein. An increase or decrease in any of these fractions (alpha 1, alpha 2, beta and/or gamma) will cause an increase or decrease in the total globulin. For this reason, care must be taken when making a diagnosis based upon the total globulin alone. Total globulin is useful with other tests for assessing degenerative, inflammatory and infectious processes and with BUN, serum phosphorus, serum, gastrin, urinary indican, subjective indicators and other tests located below to confirm a need for HCI.

About 90% of the alpha-1-globulin is alpha-1-antitrysin. It is a circulating inhibitor of proteolysis. A deficiency is associated with both lung and liver disease. Alpha-1-antitrypsin is also an acute-phase reactant protein and elevated levels are seen in and chronic inflammatory disorders.

#### Clinical Significance

Increased levels:

- Hypochlorhydria
- Liver dysfunction/Hepatic infections
- Neoplasm

Decreased levels:

Digestive dysfunction (primary inflammation or inflammation secondary to HCI insufficiency)

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#### AG/Ratio

The value of the A/G Ratio is limited because of the countless number of variables in the components comprising total globulin (alpha 1, alpha 2, beta and gamma). An abnormal A/G ration, often called a suppressed, low or reversed ratio, is generally considered a reflection of hepatic dysfunction.

#### Clinical Significance

Increased levels: Not considered significant

#### Decreased levels:

- Liver/biliary dysfunction
- Chronic renal disease
- Some types of cancer
- Sarcoidosis
- Collagen diseases
- Severe infections
- Systemic inflammation
- Burns
- Digestive inflammation

#### **Glucose**

Glucose levels are influenced by carbohydrate intake, stress, glandular and liver function.

#### Clinical Significance

Increased levels: Fasting glucose

- Acute stress response
- Diabetes: Triglycerides increased and often increased above the cholesterol level when a Type IV
   Hyperlipoproteinemia is present (Metabolic Syndrome/Syndrome –X)
- Thiamine insufficiency
- Dysinsulinism

- Fasting hypoglycemia
- Sever liver disease
- Hypothyroidism

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#### BUN

BUN reflects the difference between production and clearance of urea. Increased BUN may be due to increased production or decreased excretion. Urea is the chief end product of protein metabolism and is formed almost entirely by the liver through the urea cycle. It is removed almost entirely by the kidneys.

#### Clinical Significance

#### Increased levels:

- Chronic renal dysfunction
- Renal hypertension
- Prescribed diuretics
- Dehydration
- Cirrhosis of the liver
- Benign prostate hypertrophy
- Urinary obstruction

#### Decreased levels:

- Liver failure
- Protein malnutrition
- Celiac

#### Creatinine

Creatinine testing is used to diagnose impaired renal function. It is a waste product formed by spontaneous decomposition of creatine which is an intrinsic substance required in the contraction of muscle; therefore patients with increased muscle mass may have slightly higher creatinine levels and patients with decreased muscle mass will have slightly lower levels of creatinine. Thus, serum creatinine is not as sensitive an indicator of early renal disease as BUN which increases more rapidly than serum creatinine in the early stages of renal disease.

#### Clinical Significance

#### Increased levels:

- Chronic renal dysfunction
- Benign prostate hypertrophy

- Serum creatinine is normally decreased with children, patients who have less than average muscle mass and geriatric patients with reduced muscle mass
- Muscle wasting diseases

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# BUN/Creatinine Ratio BU/CR RA

The BUN/Creatinine ratio is useful when assessing patients with chronic renal dysfunction; however, the ratio may be skewed when a high normal BUN is present with a low normal creatinine or a high normal creatinine with a low normal BUN. Therefore, the ratio is generally not as valuable diagnostically as the quantitative BUN and creatinine.

#### Clinical Significance

#### Increased levels:

- Congestive heart failure
- Intestinal bleeding
- Shock
- Hypotension
- Dehydration
- Renal disease

#### Decreased levels:

- Low protein diets
- Malnutrition

#### Calcium

Calcium is absorbed from the upper part of the small intestine. The amount of absorption depends upon the acidity of the intestinal contents and the amount of phosphate present. Calcium relates to bone metabolism, the drawing of fats through the intestinal wall and protein absorption. The amount of protein in the blood affects the calcium level. Calcium provides a mobilizing factor in trauma, infections, stress and is used rapidly for repair of tissue in conjunction with vitamin A, vitamin C, magnesium, phosphorus, iodine and unsaturated fatty acids. Calcium exists in the ionized form (about 55 percent) and the non-diffusible form (about 45 percent), which is bound to protein (chiefly albumin). Note: in the diagnosis of hypercalcemia, serum calcium should be measured at least three times because serum calcium can change significantly when the albumin is increased or decreased.

#### Interpretation of Serum Calcium

Total serum calcium levels in patients with low or high serum albumin levels may not reflect the levels of ionized (free) calcium levels. For each 1g/dL decrease in serum albumin level, total serum calcium will be reduced by 0.8 mg/dL. This decrease will not affect the ionized calcium levels. In patients with hypoalbuminemia or hyperalbuminemia, serum calcium levels should be corrected by using the following formula:

Corrected calcium =  $[0.8 \times (4.0 - patient's albumin)] + serum calcium$ 

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#### Calcium (con't)

#### Clinical Significance

#### Increased levels:

- Parathyroid hyperfunction
- Cancer.
- Hypervitaminosis D
- Sarcoidosis

#### Decreased levels:

- Parathyroid hypofunction
- Digestive dysfunction (hypochlorhydria)
- Low normal total protein or albumin: Slight decreases of calcium are common with low total protein or albumin. Serum calcium measures total calcium, about half of which is bound to plasma proteins.
- Vitamin D insufficiency
- Protein malnutrition
- Osteoporosis
- Pancreatitis

#### Serum Sodium

Sodium is the most abundant cation in the extra-cellular fluid. It is most important in osmotic regulation of extra-cellular fluid balance, acid-base balance and renal, cardiac, and adrenal function. Its primary function in the body is to chemically maintain osmotic pressure and acid-base balance and to transmit nerve impulses. Aldosterone causes conservation of sodium. ADH controls the reabsorption of water in the kidneys, affecting sodium levels by dilution and concentration.

#### Clinical Significance

#### Increased levels:

- Chronic renal dysfunction
- Dehydration
- Adrenal cortical hyperfunction

- Adrenal cortical hypofunction
- Diarrhea

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#### Potassium

Potassium is the major cation found in the intracellular fluid. Only a small part of the total body potassium stores are contained in the serum/plasma. Potassium is also essential to maintenance of pH (blood and urine) and maintenance of osmotic pressure. Potassium should always be viewed in relation to the other electrolytes. Intracellular concentration is about 150 mEq/L and serum concentration is about 4 mEq/L. This ratio is a determinant factor in maintaining membrane electrical potential, which is important for neuromuscular tissue.

#### Potassium (con't)

#### Symptoms of hyperkalemia:

- Nausea
- Vomiting
- Intestinal colic
- Diarrhea

#### Symptoms of hypokalemia:

- Decreased contractibility of smooth, skeletal and cardia muscles
- Weakness
- Paralysis

#### Clinical Significance

#### Increased levels:

- Adrenal cortical hypofunction
- Renal dysfunction

- Diarrhea
- Adrenal cortical hyperfunction
- Drug diuretics

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#### Chloride

Chloride is the principle anion found in the serum. The chloride level along with sodium, potassium and CO2, are important in evaluating acid-base relationships, state of hydration, as well as adrenal and renal function. Chloride concentration usually varies inversely with CO2; hence, increased chloride is commonly associated with renal or systemic acidosis and decreased chloride with systemic alkalosis. Chloride is one of the elements required for the production of HCI by the chief cells of the stomach.

#### Clinical Significance

Increased levels:

- Renal dysfunction
- Dehydration

Decreased levels:

Hypochlorhydria

#### CO/2

CO2 is the amount of base bound as bicarbonate in the blood that is available for the neutralization of fixed acids such as lactic acid and hydrochloric acid. CO2 refers only to base bound as bicarbonate and not the total base of the blood. CO2 represents the reserve of alkali readily available for the neutralization of acids. Conditions involving primary CO2 excess and deficit cannot be determined by CO2 alone, serum chloride must be checked for inverse values when metabolic alkalosis is suspected, however, irrespective of the chloride value when the CO2 is 25 or less, the probability of systemic acidosis is very high.

#### Clinical Significance

Increased levels:

- Metabolic alkalosis
- Vomiting

- Thiamine deficiency: Anion gap is generally increased
- Diabetes
- Metabolic acidosis

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#### Additional Metabolic Tests

#### <u>GGT</u> Gamma-Glutamyl Transpeptidase

GGTP is a more sensitive and specific indicator of liver dysfunction than serum alkaline phosphatase (ALP) and in some conditions than SGPT/ALT. it is increased in all common forms of liver/biliary dysfunction and is generally increased above SGPT/ALT and SGOT/AST with biliary tree problems (gall bladder, common bile duct, and pancreas), obstructive disease and alcoholism.

#### Clinical Significance

#### Increased levels:

- Biliary obstruction
- Alcoholism
- Bile duct and gall bladder inflammation/Biliary insufficiency/Biliary Stasis
- Acute and chronic pancreatitis/Pancreatic insufficiency

#### Decreased levels:

Vitamin B6 anemia: generally decreased below 10

\*Increased GGTP with an increased serum alkaline phosphatase (ALP) indicates a probable liver/biliary problem. A normal GGTP with an increased serum ALP indicates a probable bone problem.

#### Hemoglobin A1c

Glycated hemoglobins are an irreversible glucose-protein bond which extends through the life of the red blood cell (90-120 days). Glycated hemoglobin values are used to assess long-term glucose control in diabetes, especially patients with insulin dependant diabetes who's urinary and fasting blood glucose levels vary significantly from day to day.

*Note:* As the RBC circulates, some of the glucose from the blood combines with hemoglobin to form glycohemoglobin. The amount of glycosolated hemoglobin found in the RBC is dependent upon the amount available in the blood.

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#### Hemoglobin A1c (con't)

#### Clinical Significance

Increased levels:

- Diabetes
- Patients with splenectomy

#### Decreased levels:

- Chronic blood loss
- Hemolytic anemia

#### Uric Acid

Uric acid is the principle end product of purine, nucleic acid and nucleoprotein metabolism.

#### Clinical Significance

Increased levels:

- Gout
- Rheumatoid arthritis

#### Decreased levels:

Molybdenum insufficiency: If the uric acid is decreased with a normal MCV/MCH, molybdenum insufficiency should be ruled out via blood or urine. Molybdenum insufficiency is common with sensitivity to perfumes, exhaust and other gases and sulfites used in food preservation.

Molybdenum is known to function as a cofactor for three enzymes:

- **Sulfite oxidase**: catalyzes the transformation of sulfite to sulfate
- Xanthine oxidase: catalyzes the breakdown of nucleotides to form uric acid
- **Aldehyde oxidase** and xanthine oxidase: catalyze hydroxylation reactions that involve a number of different molecules with similar chemical structures.

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Mod 1 \* Lesson 7: Blood Chemistry & CBC Analysis

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#### **Phosphorus**

Several factors are important in regulating serum phosphorus, including the parathyroid hormone (PTH) and the functional state of the kidneys. PTH is mostly responsible for increased serum calcium and decreased serum phosphorus; hence there is a reciprocal relationship between the two. Phosphorus is very important in the physiology of bone and in the formation of active compounds such as phospholipids, nucleic acids, ATP, creatine phosphate and complexes required for the utilization of glucose. Phosphorus is a general indicator of digestive function, when decreased <3.0 with an increased (>2.8) or decreased (<2.4) total serum globulin and/or increased BUN (>15), hypochlorhydria is probable.

#### Clinical Significance

#### Increased levels:

- Parathyroid hypofunction
- Acute and chronic renal dysfunction
- Sarcoidosis

#### Decreased levels:

- Parathyroid hyperfunction
- Digestive dysfunction (Hypochlorhydria)
- Vitamin D deficiency

#### Anion Gap

Anion gap is a calculation from sodium, potassium, CO2 and chloride to ascertain the level of unmeasured anions and cations. (Sodium + Potassium) – (chloride + CO2)

#### Clinical Significance

#### Increased levels:

- Thiamine deficiency
- Diabetes
- Lactic acidosis
- Dehydration
- Toxin ingestion
- Metabolic acidosis
- Renal dysfunction

- Renal dysfunction
- Lithium toxicity

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#### Lipid Panel

#### Cholesterol

Cholesterol is a steroid normally found in all body cells and plasma. Most of the information relative to increased or decreased cholesterol can be extrapolated to triglycerides. In general, cholesterol is increased in most endocrine or organ hypofunction and decreased in most endocrine and organ hyperfunction.

#### Clinical Significance

#### Increased levels:

- Coronary artery disease
- Diabetes
- Primary thyroid hypofunction or hypofunction secondary to anterior pituitary hypofunction

#### Decreased levels

- Thyroid hyperfunction and/or anterior pituitary hyperfunction
- Cancer
- Crohn's disease
- Cirrhosis of the liver,
- Celiac disease
- Malnutrition

#### **Triglycerides**

Serum triglycerides (TG) are a family of complex lipids composed of glycerol esterified with three fatty acids (saturated and unsaturated) of the same or different lengths. They are not soluble in blood and constitute 95 percent of the fat stored in adipose tissue. Triglycerides travel in the blood with cholesterol; therefore they should be drawn together and viewed together. A patient who is correctly metabolizing their fats, proteins, and carbohydrates will generally have about half as much triglyceride as cholesterol. Example – if the serum cholesterol is 200 the triglyceride level should be around 100. Classic research fro the Framingham studies in the 1970s identified high serum cholesterol as a heart disease risk factor (above 200 mg/dL); however subsequent Framingham studies as well as other peer reviewed studies (Helsinki, etc), indicated that increased triglycerides in conjunction with decreased HDL cholesterol (Metabolic Syndrome/Syndrome-X) was a more significant indicator for coronary artery disease than high serum cholesterol alone.

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#### *Triglycerides (con't)*

#### Clinical Significance

#### Increased levels:

- Dysinsulinism (Metabolic Syndrome/Syndrome-X)
- Hypothyroidism

#### Decreased levels:

- Thyroid Hyperfunction
- Vegetarian diets
- Autoimmune phenomenon: cholesterol will be normal to mildly decreased, triglycerides will be significantly
  decreased in relation to cholesterol (usually less than 30 percent of the total cholesterol) and the HDL
  cholesterol will be significantly increased in relation to the total cholesterol.
- Genetic predisposition
- Cirrhosis of the liver
- Celiac disease

# <u>HDL</u>

#### High Density Lipoprotein Cholesterol

HDL is a class of heterogeneous particles of varying density and size containing lipid and protein. It includes cholesterol, triglycerides, phospholipids and apoproteins. Phospholipids predominate in HDL. HDL functions in the transport of cholesterol to the liver for metabolism to bile acids, hence it is thought of as the 'good' form of cholesterol. HDL levels must be viewed in relation to the total cholesterol and LDL/VLDL cholesterol. Within reason, if the cholesterol is high, but the HDL is also high and the LDL is normal, the patient is considered to be well protected.

#### Clinical Significance

#### Increased levels:

 Increased HDL cholesterol is generally not considered to be a pathologic finding, however it is often found significantly higher than normal with alcoholism and autoimmune diseases

- Thyroid hyperfunction
- Diabetes
- Dysinsulinism (Metabolic Syndrome/Syndrome-X)

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#### <u>LDL</u> <u>Low Density Lipoprotein Cholesterol</u>

An association exists between LDL and HDL cholesterol. As the LDL increased the HDL will generally decrease; hence the association in the diagnosis of atherosclerosis, dysinsulinism, coronary artery disease and frank or developing diabetes. In most cases the LDL level is a major part of the decision relevant to initiation of dietary therapy and/or supplemental support.

Good scientific evidence exists that indicated oxidized LDL cholesterol is taken up by macrophages forming the foam cells of atherosclerotic plaques, phenolic substances (red wine, fruits and vegetables, etc. and vitamin E) <u>prevent the</u> oxidation of LDL cholesterol.

#### Hs-CRP

C-reactive protein (CRP) is produced primarily by the liver during an acute inflammatory process or other disease. It rises rapidly, but nonspecifically in response to tissue injury and inflammation. CRP is a more sensitive indicator of inflammation than the erythrocyte sedimentation rate. CRP is an excellent test to monitor the efficacy of supplements or prescribed drugs on systemic inflammation or injury.

#### Clinical Significance

#### Increased levels:

- Viral and bacterial infection
- Non specific tissue inflammation or injury
- Coronary artery inflammation/atherosclerosis
- Rheumatoid arthritis

#### Iron Panel

#### Iron

A common mistake made by many doctors when ordering a red blood count and indices is not ordering a serum iron and serum ferritin. Without the serum iron or ferritin value, the amount of inorganic iron (serum iron) or stored iron (ferritin) available to convert to hemoglobin (organic iron) is unknown.

Daily iron loss is small and occurs mainly in the feces - about 0.6 mg per day. In premenopausal women, iron losses can be up to 1.3 mg per day.

Never give iron without the benefit of a blood test because of the possibility of iron toxicity or overload.

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#### Iron (con't)

#### Clinical Significance

#### Increased levels:

- Hemochromatosis
- Hepatic dysfunction

#### Decreased levels:

- Chronic blood loss
- Iron deficiency anemia
- Menses
- Cancer
- Hepatic dysfunction
- Crohn's disease

#### TIBC

#### **Total Iron Binding Capacity**

Transferrin is responsible for 50 to 70 percent of the iron binding capacity of the serum. TIBC is the measurement of all proteins available for binding iron.

#### Clinical Significance

#### Increased levels:

Iron anemia

#### Decreased levels:

- Inflammatory diseases
- Cirrhosis

#### **Ferritin**

Ferritin is the second most abundant iron-bearing protein in the body. It functions as an iron storage depot in the liver, spleen, and bone marrow. Circulating ferritin levels appear to reflect the distribution of iron between the reticuloendothelial system (RES) cells and blood cells. Three factors generally determine serum ferritin levels:

- 1. The iron content of the body tissues.
- 2. The rate of ferritin dispersal from the tissues
- 3. The rate of ferritin extraction from the blood.

Aberrations in the latter two regulatory processes are present in many free radical diseases (cancer, rheumatoid, arthritis, etc.)

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#### Ferritin (con't)

#### Clinical Significance

#### Increased levels:

- Iron overload/Hemochromatosis
- Inflammatory disease
- Hepatitis
- HIV infection
- Cancer

#### Decreased levels:

- Iron deficiency anemia

#### **Thyroid Panel**

#### <u>sTSH</u>

#### Serum Thyroid Stimulating Hormone

The TSH assay was originally used to confirm or rule out primary thyroid hypofunction: however, the new sensitive TSH (sTSH) assays permit recognition of thyroid hyperfunction as well. Sensitive TSH (sTSH) has become the best single test for determining thyroid hypo and hyperfunction.

#### Clinical Significance

#### Increased levels:

- Primary thyroid hypofunction
- Liver dysfunction
- Large doses of iodine
- HIV

#### Decreased levels:

Thyroid hyperfunction secondary to anterior pituitary hypofunction

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#### <u>Serum Thyroxine (T4)</u> Free and Total

T4 is the major hormone secreted by the thyroid gland. It is transported through the blood bound to thyroxine binding globulin (TBG), prealbumin and albumin. Alterations in binding capacity or the quantity of TBG may increase or decrease total T4 without causing symptoms. T4 secretion is stimulated by thyroid stimulating hormone (TSH). **Free T4** is a very small portion of total thyroxine (generally less than 0.04 percent); however, it is the metabolically active fraction.

#### <u>Triiodothryonine (T3)</u> <u>Free and Total</u>

T3 is a thyroid hormone produced mainly from peripheral conversion of thyroxine (T4). Approximately one third of T4 is converted to T3. T3 has a higher biological activity than T4 and will bind to protein (thyroid binding globulin, transthyretin, and albumin) less efficiently than T4. T3 and T4 exist in the serum in both bound and free forms.

#### T3 and T4

#### Clinical Significance

Increased levels:

- Primary hyperthyroidism (Graves)
- Acute thyroiditis (Early Hashimoto's)

#### Decreased levels:

- Hypothyroidism
- Hepatic disease
- Iodine insufficiency
- Cushing's disease

#### Additional Tests/Analytes

#### Vitamin D 25-OH

Beyond osteoporosis, negative health effects of vitamin D insufficiency include strong influences on the development of cancer and autoimmune diseases, such as insulin-dependent diabetes and multiple sclerosis. Vitamin D up-regulates the immune response and down-regulates cell proliferation and inflammation.

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#### Vitamin D 25-OH (con't)

#### Clinical Significance

#### Increased levels:

Vitamin D toxicity (hypercalcemia)

#### Decreased levels:

- Rickets (children) osteomalacia (adults)
- Osteoporosis
- Diabetes mellitus
- Osteoarthritis
- Hypertension
- Cardiovascular disease
- Metabolic syndrome
- Depression
- Cancers of the breast, prostate, and colon
- Musculoskeletal pain
- Chronic low-back pain
- Inflammation

#### Creatinine Clearance

- Normal findings
  - Adult (<40 yrs)</li>

Male: 107-139 mL/min Female: 87-107 mL/min

- Values decrease 6.5 mL/min/decade of life after age 20 years with decline in glomerular filtration rate (GFR).
- Indications
  - The creatinine clearance is used to measure the GFR of the kidney.
- Creatinine is excreted entirely by the kidneys and therefore is directly proportional to the GFR (i.e., the number of milliliters of filtrate made by the kidneys per minute)
- The CrCl test requires a 24-hour urine collection and a serum creatinine level. CrCl is then computed using the following formula:

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#### Creatinine Clearance (con't)

#### Creatinine clearance = UV/P

U= number of milligrams per deciliter of creatinine excreted in the urine over 24 hours

V= volume of urine in milliliters per minute

**P**= serum creatinine in milligrams per deciliter

#### Clinical Significance

- Increased Levels
  - Exercise
  - Pregnancy
  - High cardiac output syndromes:

As blood flow increases to the kidney, GFR and CrCl increase.

- Decreased Levels
  - Impaired kidney function (e.g., renal artery atherosclerosis, glomerulonephritis, acute tubular necrosis
  - Conditions causing decreased GFR (e.g., congestive heart failure [CHF], cirrhosis with ascites, shock, dehydration

Conditions that are associated with decreased blood flow to the kidney will decrease GFR.

#### Glomerular Filtration Rate, estimated (eGFR)

- Early detection of chronic kidney disease
- Chronic kidney disease is defined as GFR <50 ml/min.
- Calculated by using serum creatinine, urea nitrogen, albumin concentration, age, sex, and race

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The following form is available at <a href="https://www.FunctionalMedicineUniversity.com">www.FunctionalMedicineUniversity.com</a> on line library.

# FUNCTIONAL MEDICINE UNIVERSITY'S BLOOD TEST RESULT TRACKING FORM (Adult Ranges)

Date:	Patient's Name:
Clinical Notes:	
Practitioner:	

#### COMPLETE BLOOD COUNT WITH DIFFERENTIAL

ANALYTE	TEST	REF.RANGE	HIGH/LOW	OPTIMAL RANGE	HIGH/LOW
	RESULT				
WBC		3.8-10.8		5-8 thous/MCL	
RBC		3.8-5.10		Male: 4.1-5.6	
				MILL/MCL	
				Female: 3.9-4.5	
HEMOGLOBIN		11.7-15.5		Male: 14.0-15.5 g/dL	
				Female: 13.5-14.5	
HEMATOCRIT		35-45		Male: 40-48 %	
				Female: 37-44%	
MCV		80-100		82-89.9 cu. microns	
MCH		27-33		27-31.9 PG	
MCHC		32-36		32-36 G/DL	
RDW		11.0-15.0		<13.0 %	
PLATLETS		140-400		140-400 thous/MCL	
MPV		7.5-11.5		7.5-11.5 FL	
ABS.		850-3900		1500-3900 cells/MCL	
LYMPHOCYTES					
NEURTOPHILS		40-74		40-60 %	
LYMPHOCYTES		14-46		24-44 %	
MONOCYTES		4-13		0-7 %	
EOSINOPHILS		0-7		0-3 %	
BASOPHILS		0-3		0-1 %	

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#### COMPREHENSIVE METABOLIC PANEL

ANALYTE	TEST RESULT	REF.RANGE	HIGH/LOW	OPTIMAL RANGE	HIGH/LOW
GGT		5-35		10-30 U/L	
LDH		100-200		140-200 U/L	
AST (SGOT)		3-35		10-30 U/L	
ALT (SGPT)		3-40		10-30 U/L	
ALK PHOS		20-125		70-100 U/L	
TOT. BILIRUBIN		0.2-1.3		0.2-1.3 mg/dL	
DIRECT BIL.		0.0-0.2		0.0-0.2 mg/dL	
INDIRECT BIL.		0.1-1.0		0.1-1.0 mg/dL	
TOT. PROTEIN		6.0-8.3		6.6-7.4 g/dL	
ALBUMIN		3.5-4.9		4.0-4.9 g/dL	
GLOBULIN		2.3-3.4		2.4-2.8 g/dL	
A/G RATIO		0.8-2.0		1.5-2.0	
GLUCOSE		65-99		80-95 mg/dL	
HGB A1c		<5.9		<5.0 %	
BUN		7-25		10-15 mg/dL	
CREATININE		0.5-1.3		0.8-1.1 mg/dL	
BU/CR RATIO		6-25		10-16	
URIC ACID		Male: 3.4-7.0		Male: 3.5-5.9 mg/dL	
		Female: 2.4-6.0		Female: 3.0-5.5 mg/dL	
CALCIUM		8.5-10.4		9.4-10.0 mg/dL	
PHOSPHORUS		2.5-4.5		3.4-4.0 mg/dL	
SODIUM		135-146		135-142 mmol/L	
POTASSIUM		3.5-5.3		4.0-4.5 mmol/L	
CHLORIDE		98-110		100-106 mmol/L	
CO2		21-33		26-31 mmol/L	
ANION GAP		8-16		8-12 mmol/L	

Clinical Notes		

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#### LIPID PANEL

ANALYTE	TEST	REF.RANGE	HIGH/LOW	OPTIMAL RANGE	HIGH/LOW
	REULT				
CHOLESTEROL		125-200		150-220 mg/dL	
TRIGLYCERIDES		<150		70-100 mg/DL (or 40-60% of	
				total cholesterol)	
HDL		>39		50-60 mg/dL	
LDL		< 100		<100 mg/dL	
Hs-CRP		< 1.0 mg/L		SAME	
		Cardiac risk			
		Low: <1.0			
		Average: 1.0-			
		3.0			
		High: >3.0			

#### **IRON PANEL**

THEOTY TITLED					
ANALYTE	TEST RESULT	REF.RANGE	HIGH/LOW	OPTIMAL RANGE	HIGH/LOW
IRON		40-175		50-100 ug/dL	
TIBC		250-450		250-350 ug/dL	
% SATURATION		15-50		20-45 %	
FERRITIN		Male: 12-300		Male: 20-200 ng/mL	
		Female: 10-150		Female: 10-110 ng/mL	

#### THYROID PANEL

ANALYTE	TEST RESULTS	REF.RANGE	HIGH/LOW	OPTIMAL RANGE	HIGH/LOW
TSH		0.4-4.5		1.5-3.0 microunits/mL	
TOT. T4		5-12		5-12 mcg/dL	
FREE T4		.8-2.4		.8-2.4 ng/dL	
TOT. T3		60-181		60-181 ng/dL	
FREE T3		230-420		230-420 pg/dL	

Clinical Notes:				

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### ADDITIONAL TEST/ANALYTES

ANALYTE	TEST	REF.RANGE	HIGH/LOW	OPTIMAL	HIGH/LOW
	RESULT			RANGE	
VITAMIN D		30 Deficient		40-65 ng/mL	
25-OH		30-100 Sufficient			
		100 Toxic			
eGFR		>60 mL/min/1.73m2			
		(<50 mL/min is defined as chronic			
		kidney disease)			

ASSESSMENT		
PLAN		
Practitioner's Signature:		
	_1/_	

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