Frequently ordered laboratory tests

Glucose, blood

Adults: 70-99 mg/dl - Renal threshold: 180 mg/dl

- Critical values for hyperglycemia in adults are >400 mg/dL
- Critical values for hypoglycemia in adult males are <50 mg/dL and adult females are <40 mg/dL.
- Fasting blood glucose is performing on serum or plasma

Glucose, blood

Glucose increased by:	***Glucose decreased by:***
Acromegaly	Addison's disease
Adenoma of pancreas	Exercise
Brain trauma	Hepatic necrosis
Cushing's syndrome	Islet cell carcinoma
Diabetes	Malabsorption
Eclampsia	Pancreatic cancer
Hyperthyroidism	Pituitary hypofunction
Liver disease	Post gastrectomy
Malnutrition	Sepsis
MI	Stress
Obesity	***Drugs that ay decrease blood glucose:***
Pancreatitis	Alcohol
Pheochromocytoma	Amphetamines
Stress (insulin resistance)	Beta-blockers
Drugs that increase blood glucose:	Ginseng
Corticosteroids	Glucasol (agestroemia speciosi L. etc)
Diuretics	Gymnema Sylvestre ext.
Epinephrine	Insulin
Glucagon	Momordica charantia (bitter melon)
Nicotine	

Glucose, Urine

24 hour specimen:

When blood glucose levels exceed 180 mg/dL the glucose begins to spill over into the urine.

Urine Glucose Increased by:

Diabetes mellitus

Cushing's syndrome

Severe stress

- trauma
- surgery

Infection

Drug therapy

Pregnancy

Low renal threshold

Decreased by:

Drugs that cause false negative test include:

Ascorbic acid (Clinistix, Tes-Tape)

Levodopa (Clinistix)

Phenazopyridine (Clinistix, Tes-Tape)

Drugs that may increase levels:

- Aminosalicylic acid
- Cephalosporins
- Chloramphenicol
- Dextrothyroxine
- Diuretics (loop and thiazide)
- Estrogens
- Glucose infusions
- Isoniazid
- Levodopa
- Lithium
- Nafcillin
- Nalidixic acid
- Nicotinic acid (large doses)

HgA1C Glycosylated Hemoglobin

Normal adult 4 – 7 %

Good diabetic control 7% or less

Fair diabetic control 7.01% - 10%

Poor diabetic control 10.1% - 13% or more

- Glycosylated hemoglobin (GHb) is a test which provides an accurate 2-3 month index of average blood glucose levels.
- If the patient has had greatly fluctuating blood glucose levels (>50 mg/dl and >200 mg/dL) the test will reflect both highs and lows. In other words, a person in poor control may have relatively good GHb values when in fact the blood glucose control has been poor.
- Test is unaffected by recent food intake, exercise, stress of hypoglycemia.

HgA1C Glycosylated Hemoglobin, cont'd

Glycosylated Hemoglobin Increased with:	**Decreased with:**
Newly diagnosed or poorly controlled diabetes Impaired Glucose Tolerance Pregnancy Fe deficiency anemia Hemodialysis Thalassemia	Hemolytic anemia (Sickle Cell) (caused by increased RBC turnover) Chronic renal failure Vitamin E supplementation

Sodium, Serum

Adults: 136-145 mEq/L

- Sodium is the major cation in extracellular space
- Intracellular sodium is approximately 5mEq/L….
- Aldosterone and antidiuretic hormone help regulate sodium balance

Symptoms of hypernatremia:

- Dehydration thirst, agitation, restlessness, hyper-reflexes and seizures.

Symptoms of hyponatremia

- Muscle cramps, muscle twitching, headache, dizziness, lethargy, confusion, convulsions, stupor and coma. The changes in the central nervous system are due to fluid shifts from the extracellular spaces to the intracellular spaces, causing cells to swell.
- Elevated blood glucose levels give falsely low serum sodium values. Use this formula to correct serum sodium values. Na= $\frac{\text{glucose}}{6} \times 2 + \text{Na}$

Sodium, Serum, Cont'd

Sodium Increased by	***Sodium decreased by***
Excessive intake	Decreased intake
Dehydration	Severe diarrhea
Excessive sweating	Vomiting
Diabetes insipidus	Hypergllycemia
Hypercalcemic nephroopathy	Hyperproteinemia
Hypokalemic nephropathy	Addison's disease
Cushing's disease	Cirrhosis with ascites
Primary aldosteronism	Excessive non-electrolyte IVs

Drugs that may increase sodium

methyldopa
antibiotics
corticosteroids
oral contraceptive agents

Drugs that may decrease sodium

diuretics
vasopressin (ADH)

Potassium, serum

Adults: 3.5 - 5.0 mEq/L

- Potassium is the principle intracellular cation.
- The normal potassium levels within cells is approximately 150 mEq/L compared to 3.5 - 5.0 mEq/L in serum
- The serum potassium concentration is related to renin-aldosterone mechanism, sodium reabsorption and acid-base balance.
- When acid-base balance is altered the serum potassium also changes. As the pH of the blood increases (becomes more alkalotic) the potassium shifts from the serum to the cells. As the pH of the blood decreases (becomes more acidic) the intracellular potassium shifts to the serum.

Potassium, serum cont'd

Symptoms of hypokalemia:

- Muscle weakness, cramps, hyporeflexia, paresthesias, decreased bowel motility, hypotension, cardiac arrhythmia, drowsiness, lethargy and coma. Serum potassium below 3.5 mEq/L is often seen with a serum pH above 7.45, decreased serum bicarbonate level and possibly elevated blood glucose.

Symptoms of hyperkalemia:

- include confusion, irritability, nausea, vomiting, intestinal colic, paresthesia abdominal cramps and muscle paralysis.

Potassium, serum cont'd

Potassium Increased by	**Decreased by**
Renal Failure Excessive intake Cell damage: > burns > surgery > crushing injuries > chemotherapy Acidosis Addison's disease Internal hemorrhage Uncontrolled diabetes Dehydration	PCM Malabsorption Diarrhea Severe vomiting Renal tubular acidosis Diuretic therapy Liver disease with ascites Chronic stress Chronic laxative abuse Cushing's syndrome IV fluids without adequate K+

Potassium, serum cont'd

Drugs which may increase K+ levels	***Drugs which may decrease K+ levels***
Antibiotics	Licorice
Antineoplastic drugs	NaCl
Captopril	Digoxin
Epinephrine	Insulin
Histamine	Laxatives
Lithium	Aspirin

Chloride, Cont'd

Adult/Ederly: **90-110** mEq/L

- Chloride is the major extracellular anion.
- Chloride works with sodium to maintain serum osmolality.
- Absorption of chloride depends on sodium reabsorption and is regulated by aldosterone. Any changes in sodium reabsorption will secondarily impact the serum chloride level. In doing so, chloride affects water balance and osmolality.
- Hypochloremia is almost always seen with hyponatremia.
- Hyperchloremia is alnost always seen with hypernatremia

Chloride, Cont'd

Symptoms of hypochloremia:

- Hyperexcitability of the nervous system and muscles, shallow breathing, hypotension and tetany.
- As the chloride level drops, the bicarbonate reabsorption increases proportionately causing metabolic alkalosis. The abnormally high level of bicarbonate results in a shift of intercellular hydrogen out of the cell and potassium into the cell. This shift results in hypokalemia.

Chloride, Cont'd

Symptoms of hyperchloremia:

- Lethargy, weakness and deep breathing,
- As the chloride level increases, the bicarbonate reabsorption decreases proportionately, causing metabolic acidosis

Chloride, Cont'd

Chloride Increased by	***Decreased by***
Dehydration	Overhydration
Excessive infusion of saline	Congestive heart failure
Cushing's syndrome	Vomiting
Eclampsia	Addison's disease
Anemia	Hypokalemia
Hypernatremia	Hyponatremia
Multiple myeloma	Diuretic therapy
Metabolic acidosis	Metabolic alkalosis
Hyperventilation	Burns
	Emphysema

Chloride, Cont'd

Drugs that may increase chloride	***Drugs that may decrease chloride***
Cortisone	Aldosterone
Estrogen	Corticosteroids
Diuretics	Hydrocortisone
NSAIDS	Diuretics

Carbon Dioxide

23-30 mEq/l

- 95% of C02 comes from bicarbononate (HCO3) which is regulated by the kidneys
- The remaining 5% comes from dissolved C02 (Carbonic acid H2CO3) which is regulated by the lungs.
- These substances assist in maintaining the body's acid-base balance through it's buffering system.

Carbon Dioxide, Cont'd

C02 increased by	***Decreased by***
Airway obstruction	Acute renal failure
Alcoholism	Dehydration
Cushing's syndrome	Diabetic acidosis
Emphysema	Diarrhea (severe)
Fat embolism	Head trauma
Hypoventilaion	High fever
Metabolic alkalosis	Hyperventilation
Nasogastric suctioning	Malabsorption
Pneumonia	Metabolic acidosis
Primary aldosteronism	Renal tubular acidosis
Pyloric obstruction	Respiratory alkalosis
Respiratory acidosis	Salyicylate intoxication
Vomiting	Starvation
	Uremia

Carbon Dioxide, Cont'd

Drugs that may increase C02	***Drugs that may decrease C02***
Aldosterone	Ammonium chloride
Antacids	Chlorothiazide diuretics
Barbituates	Methacillin
Cortisone	Salicylates
Licorice	Tetracycline
Loop diuretics	
Sodium bicarbonate	
Thiazide diuretics	

Blood Urea Nitrogen (BUN)

Adults: 7-23 mg/dL

- The BUN level is directly related to the metabolic function of the liver and excretory function of the kidney.
- The BUN increases as the kidney's function declines. Slightly higher values of BUN seen in elderly patients are often the result of an inability to concentrate urine or dehydration.

Blood Urea Nitrogen (BUN) Cont'd

- The BUN is interpreted in conjunction with the creatinine test to assess kidney excretory function.
- A BUN>100 mg/dL usually indicates serious kidney problems.
- In patients with both kidney disease and liver disease, the BUN may be elevated then return to normal. This is not a reflection of improved renal excretory function but rather an indication that the liver is unable to form urea. As the liver continues to decline, the blood ammonia levels will rise, while the BUN may remain normal or slightly elevated.

Blood Urea Nitrogen (BUN) Cont'd

BUN Increased by	**Decreased by**
Increased Protein catabolism:	Severe liver damage:
Hemorrhage into GI	▫drugs
Acute MI	▫poisoning
Stress	▫hepatitis
Starvation	Increased protein synthesis:
Diabetes	▫Late pregnancy
Fever	▫Infancy
Bums	▫Acromegaly
Impaired renal function	Nephrotic syndrome
CHF	Impaired absorption
Urinary obstruction	▫Celiac disease
Dehydration	Low protein, high CHO diet
Very high protein diet	Overhydration

Blood Urea Nitrogen (BUN) Cont'd

Drugs that may increase BUN levels	***Drugs that may decrease BUN levels***
Allopurinol Aminoglycosides Cephalosporins Furosemide Guanethidine Indomethacin Methotrexate Methyldopa Aspirin Bacitracin Carbamazepine Neomycin Penicillamine Propranolol Spironolactone Tetracyclines	Chloramphenicol Streptomycin

Creatinine

Adult males: 0.9 - 1.3 mg/dL;

Adult females: 0.6 - 1.1 mg/dL;

- Creatinine is a by-product of the metabolism of muscle creatine phosphate to form ATP.
- Critical values >4 mg/dL indicate serious impairment in renal function. However, a normal creatinine does not always mean unimpaired renal function.
- Unlike the BUN, creatinine is not affected by malnutrition or hepatic function.

Creatinine, Cont'd

Creatinine increased by:

Acromegaly
CHF
Diabetic nephropathy
Impaired renal function
Nephritis
Reduced renal blood flow:

- Shock
- Dehydration
- Congestive heart failure

Rapid muscle loss
Rhabdomyolysis
Surgery
Trauma
Urinary tract obstruction
Uremia

Decreased by:

Debilitation
Muscular dystrophy

Drugs that may decrease Creatinine:

Diuretics
Marijuana

Creatinine, Cont'd

Drugs that may increase Creatinine:

Cimetidine
Aminoglycosides
Cephalosporins
Heavy metals chemotherapeutic agents
Creatine supplementation
Protein
Pyruvate
Testosterone
Arginine
Barbituates
Corticosteroids

Creatinine Clearance

Adults < 40 yr: Male: 90-139 mL/min
Female: 80-125 mL/min

Values decrease 6.5 mL/min/decade due to decline in glomerular filtration rate (GFR)

The creatinine clearance test is used to evaluate glomerular filtration rate in terms of milliliters of filtrate produced by kidneys per minute.

The creatinine clearance test is used to assess the ability of the glomeruli to act as a filter.

Creatinine Clearance, Cont'd

Creatinine Clearance = $\frac{UV}{P}$

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

V = volume of urine in milliliters per minute

P = serum creatinine in milligrams per deciliter

- Conditions which impact the results include a decrease in blood present for filtration and an inability of the glomeruli to act as a filter. A decrease in blood present for filtration can be due to renal artery atherosclerosis, dehydration or shock. Diseases affecting the glomeruli include glomerulonephritis, acute tubular necrosis and other primary renal diseases.

Creatinine Clearance, Cont'd

Creatinine Clearance Increased by:

Exercise

Pregnancy

Drugs that may increase levels:

Aminoglycosides:

Gentamicin

Cimetidine

Heavy-metal chemotherapeutic agents:

- Cisplatin

Nephrotoxic drugs:

- Cephalosporins
- Cefoxitin

Decreased by:

Impaired kidney function

Renal artery atherosclerosis

Glomerulonephritis

Acute tubular necrosis

Dehydration

Congestive heart failure

Cirrhosis with ascites

Shock

Uric Acid

Female 2.3 – 6.6 mg/dL

Male 3.6 – 8.5 mg/dL

- The end product of purine metabolism during the formation and degradation of DNA and RNA, plus the metabolism of dietary purines.
- The test is used to evaluate gout, kidney failure, leukemia, and toxemia of pregnancy.

Uric Acid, Cont'd

Uric Acid Increased by	***Decreased by***
Acute leukemia Alcoholism Anemia Congestive heart failure Dehydration Down syndrome Eclampsia Fasting Glomerulonephritis Gouty arthritis Hypothyroidism' Hypoparathyroidism Infectious mono Lead poisoning Lymphomas Malnutrition Neoplasms Nephritis Polycythemia vera Radiation Renal failure Shock Uremia	Acromegaly Celiac disease Hodgkin's disease Liver disease Neoploasms Renal tubular defects SIADH Wilson's disease Xanthinuria

Phosphorus

2.7 – 4.5 mg/dl

- The main anion in intracellular fluid
- Functions in glucose and lipid metabolism, bone formation, and acid-base balance.
- Like calcium, it is controlled by parathyroid hormone. An excess of one causes the kidneys to excrete the other.

Phosphorus, Cont'd

Phosphorus increased by	***Decreased by:***
Acromegaly	Antacid abuse
Addison's disease	Carbohydrate loading
Bone tumors	Chronic alcoholism
Excessive intake of alkali	Diabetic acidosis
Healing fracture	Diuresis
Hypocalcemia	Hypercalcemia
Hypoparathyroidism	Hyperinsulinism
Massive blood transfusions	Hyperparathyroidism
Nephritis	Malabsorption
Prepuberty	Malnutrition
Renal failure	Osteomalacia
Sarcoidosis	Rickets
Uremia	Salicylate intoxication
Vitamin D intoxication	Vitamin D deficienty

Phosphorus, Cont'd

Drugs that may increase Phosphorus	***Drugs that may decrease phorphorus***
Heparin	Anabolic steroids
Phenytoin	Androgens
Methicillin sodium	Antacids
Phosphate enemas	Diuretics
	Epinephrine
	Glucagon
	Glucose
	Insulin
	Mannitol
	Salicylates

Calcium 8.6 – 10 mg/dL

- Serum calcium levels are used to evaluate parathyroid function and calcium metabolism.
- Critical values are <6 mg/dL possibly leading to tetany and >14mg/dL possibly leading to coma.
- The total serum calcium value includes both ionized calcium and calcium bound to albumin. When the serum albumin is low, the serum calcium level will also be low.
- When the serum albumin is high the serum calcium level is elevated.

Calcium

Calcium Increased by	*Decreased by*
Mesastic tumor to the bone	Hypoparathyroidism
Hyperparathyroidism	Renal failure
Vitamin D intoxication	Rickets
Sarcoidosis	Osteomalacia
Milk-alkali syndrome	Hyperphosphatemia secondary to renal failure renal failure
Addison’s disease	Vitamin D deficiency
Paget's disease of bone	Malabsorption
Nonparathyroid PTH producing tumors (e.g.,lung and renal carcinomas)	Pancreatitis
Acromegaly	

Calcium

Drugs that may increase levels	***Drugs that may decrease levels***
Calcium supplements	Barbituates
Anabolic steroids	Iron
Antacids	Magnesium
Thiazide diuretics	Aspirin
Parathyroid hormone (PTH)	Calcitonin
Thyroid hormone	Corticosteroids
Vitamins A and D	Heparin
	Laxatives
	Loop diuretics

Cholesterol, Total

Adult: Total Cholesterol <200 mg/dL
Adult: LDL - 60-160 mg/dl (other labs 60-130)
Adult: HDL - Male >45 mg
Female > 55 mg
Adult: VLDL - 25% - 50%

- Cholesterol can be synthesized from acetyl coenzyme A in many tissues in the body.
- Low levels of total cholesterol are associated with malnutrition. In elderly patients/residents a total cholesterol level <160 mg/dL is a risk factor for skin breakdown when other risk factors are present.
- Can be used as a screening tool to identify individuals at risk for developing pressure ulcers.
- Low levels may also indicate severe liver disease or malabsorption syndromes.

Cholesterol, Total

Cholesterol Increased by:	*Decreased by*
Diabetes	Malabsorption
High calorie diet	PCM
Hypothyroidism	Hyperthyroidism
Hypertension	Pemicious aneniia
Nephrotic syndrome	Hemolytic anemia
Pregnancy	Sepsis
Stress	Stress
Biliary cirrhosis	Liver disease
	AIDS

Cholesterol, Total

Drugs that may increase cholesterol	*Drugs that may decrease cholesterol*
ACTH	Allupurinol
Anabolic steroids	Androgens
Beta blockers	Bile-salt binding agents
Corticosteroids	Erythromycin
Epinephrine	Cytomel
Oral contraceptive agents	Niacin
Dilantin	Mevacor
Thiazide diuretics	Neomycin

Triglycerides

Adult: Males 40-100 mg/dl
Females 35-100 mg/dl

Triglycerides increased by:

MI
High (excessive) calorie intake
High CHO diet or High Fat Diet
Poorly controlled diabetes
Nephrotic syndrome
Alcoholic cirrhosis
Alcohol

Drugs that may increase levels:

Cholestyramine
Estrogen
Oral contraceptive agents

Decreased by:

Malabsorption
PCM
Hyperthyroidism
AIDS

Drugs that may decreased levels:

Ascorbic acid
Clofibrate
Cholesterol

Protein, Total

Adults: 6.0 - 8.0 gm/dL

- Total protein is a measure of the albumin and globulin in the blood
- It is of little value as a sensitive index of protein intake and protein status.

Total Protein increased by:

Dehydration

Decreased by:

PCM

Fluid overload

Hepatic diseases

Severe infection

AIDS

Protein-losing nephropathies'

Third-space losses:

- ascites
- burns

PCM

Lupus

Albumin

Adults: 4.0 - 6.0 gm/dL (labs vary)

Degree of depletion

Mild: 3.0-3.5, gm/dL moderate: 2.1-3.0 gm/dL severe: <2.1 gm/dL

- Albumin is synthesized in the liver at a rate of 8-14 grams/day. It makes up approximately 60% of the total protein.
- Albumin provides approximately 80% of colloidal osmotic pressure of the
- Albumin also serves as a carrier of metals, ions, fatty acids, amino acids, metabolites, bilirubin, enzymes, hormones and drugs.
- Albumin level is dependent upon hepatocyte function. With age and declining liver function the liver can lose its ability to synthesize albumin.
- Because the half-fife of albumin is 12-21 days, significant changes in liver n specific to albumin synthesis may go undetected until after that point.
- Severely malnourished individuals have greatly decreased levels of serum albumin. *However, albumin is a poor indicator of early malnutrition because of its long half-life.*
- When albumin levels are low the serum calcium level is also low.
- When the serum albumin is elevated the serum calcium is elevated.

Albumin, Cont'd

Albumin Increased by:
Dehydration

Drugs that may increase levels:
Anabolic steroids
Androgens
Corticosteroids
Insulin
Progesterone

Drugs that may decrease levels:

Estogens
Hepatotoxic drugs
Oral contraceptive agents

Albumin Decreased by:
Overhydration
Decreased absorption:
pancreatic insufficiency
Malabsorption
Inadequate intake
Impaired synthesis:
CHF
Cirrhosis
Acute stress
Increased need:
Hyperthyroidism
Pregnancy

Albumin decreased by
Increased loss:
Edema
Ascites
Burns
Pressure ulcers
Hemorrhage
Nephrotic syndrome
Crohn's disease
Sprue
Whipple's disease
AIDS

Bilirubin, Total

Total: 0.1 - 1.0 mg/dL

Direct: (conjugated) .01-.4 mg/dL

Indirect: (unconjugated) I - 1.0 mg/dL

Normally 70-85% of total bilirubin is conjugated.

- Metabo@m: Breakdown of RBC in reticuloendothelial system (macrophages-) Hemoglobin released from RBCs & broken down to heme & globin.
- Heme → bihverdin → bilirubin
- Bifirubin is conjugated in the liver with a glucuronide
- After conjugation, bilirubin excreted into intrahepatic canaculi → then hepatic ducts → bile duct → bowel
- Jaundice Occurs when total serum bilirubin exceeds 2.5 mg/dl
- Once jaundice occurs: Is it direct or indirect? (Conjugated or unconjugated?)
  - Liver dysfunction → unconjugated biliribin
  - Bile duct obstruction → conjugated bilirubi
  - Newborn jaundice occurs when immature liver does not have enough conjugating enzyme

Lactic Dehydrogenase (LDH)

Adult/Elderly: 110-210 U/L

Isoenzymes in adult/elderly:

LDH-1:	17%-27%	heart & blood vessels
LDH-2:	27% -37%	reticuloendothelial system
LDH-3:	18% - 25%	lungs
LDH-4:	3%- 8%	kidney, placenta, pancreas
LDH-5:	00/o - 5%	liver and striated muscle

Lactic Dehydrogenase (LDH), Cont'd

- Lactic dehydrogenase (LDH) is an enzyme found in heart, liver, skeletal muscle, brain, red blood cells and lung cells.
- It rises within 24 to 72 hours after a myocardial infarction, peaks in 3 to 4 days and returns to normal in about 14 days.
- Lactic dehydrogenase is used with creatinine phosphokinase MB isoenzyme and aspartate ammotransferase to diagnose a myocardial infarction.
- LDH-2 levels are normally higher than the other isoenzymes. When LDH-1 is elevated above LDH-2 it suggests a possible myocardial Actions If the laboratory only assesses for LDH-1 look for a level greater than 40% to suggest a myocardial infarction.

Lactic Dehydrogenase (LDH), Cont'd

LDH Increased by:

- Myocardial Actions pulmonary infarction, hepatic diseases, hemolytic anemias, skeletal muscle disease and injury, renal parenchymal diseases, intestinal ischemia infarction, cerebrovascular accident, neoplastic states, infectious mononucleosis, heat stroke, pancreatitis, collagen diseases, fracture, muscular dystrophy, shock, hypotension

Drugs that may increase levels:

- Alcohol anesthetics, aspirin, clofibrate, fluorides, mithramycin, narcotics, procainamide

Creatinine Phosphokinase (CPK)

Total CPK

Adult/Elderly:	Male	12 - 17 U/mL
	Female:	10 - 55 U/mL

Isoenzymes

CPK-MM - 100%	skeletal muscle
CPK-MB - 0%	specific for myocardial cells
CPK-BB - 0%	brain & lung

Creatinine Phosphokinase (CPK), Cont'd

- Creatinine phosphokinase (CPK) is an enzyme found in the heart, muscle, skeletal muscle and brain. Elevations in serum creatinine phosphokinase are always due to damaged muscle cells. The CPK levels often rise within 6 hours after trauma, peak at 18 hours and return to normal in 2 to 3 days if no additional injury occurs.
- Elevations in creatinine phosphokinase are often associated with a myocardial infarction. The CPK-MB appears to be specific for myocardial cells. The CPK-MB levels rise 3 to 6 hours after a myocardial infarction, peak at 12 to 24 hours and return to normal in 12 to 48 hours. If additional myocardial damage occurs, the CPK-MB will begin to rise again. CPK-MB levels usually do not rise with chest pain caused by angina, pulmonary embolism or congestive heart failure.
- Elevations in the CPK-BB are associated with a cerebrovascular accident or pulmonary infarction.
- When the CPK level increases due to an elevation in CPK-MM it is likely due to injury or stress to the skeletal muscle.

Creatinine Phosphokinase (CPK), Cont'd

Creatinine Phosphokinase
Increased by:
Acute myocardial infarction
Acute cerebrovascular disease
Electric shock
Convulsions
Muscular dystrophy
Delirium tremens
Chronic alcoholism
Polymyositis
Hypokalemia
Central nervous system trauma
Pulmonary infarction
Dermatomyositis

CPK-BB isoenzyme
Increased by:
Pulmonary infarction
Electroconvulsive therapy
Brain injury
Cerebrovascular accident (stroke)
Shock
Adenocarcinoma
Intestinal ischernia
Pulmonary embolism
Subarachnoid hemorrhage
Seizures
Brain cancer

Troponins

Cardiac troponin T (cTnT) <0,2 ng/mL

Cardiac troponin I (ctnl) <0.03 ng/mL

- New biochemical markers for heart disease
- They become elevated quicker and stay elevated longer than CPK-MB
- Increased levels = myocardial injury or myocardial infarction
- Severe skeletal muscle may cause false elevation of cTnT.

Lymphocytes (20-40%)

- Lymphocytes fight chronic bacterial infections and acute viral infections.
- Lymphocytes are either T-cells or B-cells.
- T-cells are primarily involved with cellular type immune reaction i.e. fungal and viral infections and transplant rejection The T-cell secretions stimulate the B-cell response.
- B-cells participate in antibody production or humoral immunity. When the humoral immunity is activated the B-cells specific to the antigen differentiate into plasma or memory cells. These cells synthesize and release antibodies or immunoglobulins. The antibody binds to the antigen and inactivates it.

Lymphocytes (20-40%), Cont'd

Lymphocytes Increased by:
(lyntphocytosis):
Cbronic bacterial infection
Viral infection
- Mumps
- Rubella

Lymphocytic leukemia
Multiple myeloma
Infectious mononucleosis
Radiation
Infectious hepatitis

Lymphocytes Decreased by:
(lymphocytopenia):
Leukemia
Sepsis
Immunodeficiency diseases
Lupus erythematosus
Later stages of HIV

Drugs that may decrease levels:
Andrenocorticosteroids
Antineoplastic
Radiation therapy

Folate

5-20 μg/ng

- Folate levels are used to evaluate hemolytic disorders and to detect megaloblastic anemias.
- Elevated levels of folate are often seen in pernicious anemia.

Folate Increased by:	***Decreased by:***
Penicious anemia	Megaloblastic anemia
Vegetarianism	Hemolytic anemia
	PCM
	Malabsorption syndromes
	Cancer
	Liver Disease
	Alcoholism

Drugs that may decrease folate levels:

Alcohol, aminopterin, aminosalicylic acid (PAS), ampicillin, antimalarials, chloramphenicol, erythromycin, estrogens, methotrexate, oral contraceptives, penicillin, phenobarbital, phenytoin, tetracycline

Vitamin B12

205-876 pg/mL

Deficient: <140 pg/mL

> Testing for Bl2 along with folic acid is used to test macrocytic anemia.

B12 increased by:	***B12 decreased by:***
COPD	Alcoholic hepatitis
CHF	Aplastic anemia
Diabetes	Cancer
Leukemia	Diet deficient in folic acid
Leukocytosis	Hemodialysis
Liver disease	Hypothyroidism
Liver metastasis	Inflammatory bowel disease
Obesity	Malabsorption
Uremia	Malnutrition
	Parasites
	Pernicious anemia
	Pregnancy
	Smoking
	Vegetarianism

Vitamin B12, Cont'd

Drugs that may increase B12

- Anticonvulsants
- Estrogens
- Vitamins A & C
- Anticonvulsants

Drugs that may decrease B12

- Aspirin
- Alcohol
- Antineoplastic agents
- Diuretics
- Oral hypoglycemics
- Sedatives
- High doses of Vitamin C

C-Reactive Protein

Adults: <0.8 mg/dL

- C-reactive protein (CRP) is an acute-phase protein which increases in infectious diseases and inflammatory disorders. It is an abnormal protein synthesized by the liver during an acute inflammatory process. An increase in CRP is associated with decreased levels of albumin and pre-albumin. A positive test indicates an acute inflammatory reaction however, it does not indicate the cause of the reaction. Antigens, immune complexes, bacteria, fungi and trauma can initiate the synthesis of CRP.
- This test is also used to monitor patients with a myocardial infarction. The level of CRP follows a similar pattern to creatine kinase MB isoenzyme, however the peak occurs one to three days later. If CRP levels do not return to less than 0.8 mg/dL, this suggests damage to heart tissue. Levels are not elevated with angina pectoris.

C-Reactive Protein, Cont'd

- CRP can be used postoperatively to identify wound infections. Generally, CRP increases four to six hours after surgery and will return to <0.8 mg/dL in three days. Elevated levels suggest complications.

CRP Increased by:

Acute rheumatic fever, Rheumatoid arthritis, Acute myocardial infarction, Postoperative wound infections, Pulmonary Actions Kidney or bone marrow transplant rejection, Malignant diseases, Bacterial infections (tuberculosis,), Viral infections, Crohn's disease, Reiter's syndrome, Vasculitis syndromes, Lupus erythematosus, Tissue necrosis or trauma

Drugs that may increase CRP levels:

oral contraceptives

Drugs that may decrease levels:

nonsteroidal anti-inflammatories
salicylates
steroids

Pre-albumin

Adults: 19-43 mg/dl

Deficiency: mild: 10-15 mg/dl

moderate: 5-10 mg/dl

severe: <5 mg/dl

- Pre-albumin (PAB) is in a class of proteins having rapid turnover with short half-lives (2-3 days). Also called transthyretin and thyroxine-binding pre-albumin.
- PAB is a transport protein synthesized by the liver and transported in serum as a complex of retinol-binding protein and vitamin A.
- PAB is a sensitive indicator of change affecting protein synthesis and catabolism. Frequently ordered to monitor TPN.
- Levels are reduced in hepatobiliary disease because of impaired synthesis.
- Serum PAB increases when more than 60% of Basal Energy Expenditure (BEE) needs are met and decreases when less than 45% are met or when there is no oral intake.
- A reasonable goal of a reseeding program is to increase serum PAB by at least 2.0-3.0 mg/dL in one week.

Pre-albumin, Cont'd

PAB Increased by:

Dehydration

Hodgkin's disease

Chronic kidney disease

Nephrotic syndrome

Decreased by

Malnutrition

Liver damage

Inflammation

Post-surgery

Bums

Overhydration

Zinc deficiency

Ferritin

Males: 12-300 ng/ml

Females: 10-150 ng/ml

- Ferritin is one of the major iron storage proteins.
- Levels of ferritin in the upper ranges are believed to correlate to increased risk for cardiovascular disease.

Ferritin, Cont'd

Ferritin Increased by:

Hemochromatosis

Hemosiderosis

Megaloblastic anemia

Hemolytic anemia

Alcoholic/inflammatory liver disease

Hodgkin's disease

Breast cancer

Decreased by:

Iron deficiency anemia

Severe protein deficiency

Hemodialysis

Retinol-Binding Protein

2.6 – 7.6 mg/dl

- A low molecular weight protein that responds to both protein and calorie restrictions.
- More affected by energy restriction than protein deficiency.
- Not affected by the acute inflammatory response like pre-albumin, albumin, or C-reactive protein.
- RBP is a more reliable indicator of nutritional status following surgery or injury. RBP has a 10 hour half life and appears to be a better indicator of both short term and long term changes in protein status than albumin, pre-albumin or transferrin.
- RBP is not a reliable indicator of protein status in advanced chronic renal disease or in advanced liver disorders.

Insulin-like Growth Factor (IGF-1) [Somatomedin C]

42-110 ng/ml

- Levels are dependent on levels of GH.
- Non-pituitary causes of reduced levels include protein-calorie malnutrition, severe chronic illness, liver disease, and hypothyroidism.
- Restoration is more dependent on protein than on energy. (In contrast, Prealbumin is more dependent on energy than on protein.)
- More sensitive and specific than albumin, pre-albumin, transfeff4 or retinol-binding protein.

Magnesium

1.3 – 2.1 mEq/L

- Most magnesium exists within cells. Half is in bone
- Most is bound to ATP, making this electrolyte important in all metabolic processes
- Neuromuscular tissue depends on magnesium, and it is especially important to monitor magnesium levels in cardiac patients.
- ***Increased by:*** Renal insufficiency, diabetes, Addison's disease, Hypothyroidism, Magnesium containing antacids
- ***Decreased by:*** Malnutrition, malabsorption, Hypoparathyroidism, Renal disease, Diabetic acidosis, stress, alcohol, diuretics, antibiotics
- ***Symptoms of deficiency:*** apathy, forgetfulness, insomnia, depression, cardiac arrhythmia, muscle spasms, twitching, a tendency to startle easily

Magnesium, Cont'd

- ***Symptoms of excess:*** *lethargy, flushing,* hypotension, respiratory depression, bradycardia
- Most frequently observed abnormal analyte in pediatric patients
- 75% of diabetic patients are deficient
- 30% of patients in intensive care have low serum levels
- Hypomagnesemia is a serious risk factor for hypertension, cardiac arrhythmia stroke & heart failure

Lipid Panel, Cont'd

HDL Increased by:	***HDL Decreased by:***
Frequent exercise	High alcohol intake
Liver disease	Smoking
Moderate alcohol intake	AIDS

LDL & VLDL Increased by:	***LDL & VLDL Decreased by:***
Excessive calories	Malnutrition
High saturated fat diet	Malabsorption

Drugs that may increase both IML & LDL:

Aspirin, oral contraceptive agents, steroids, sulfonamides

Homocysteine

7-22 μmol/L

- Elevated levels are associated with an increased risk for heart disease that is independent of lipid levels.
- Homocysteine is an intermediate metabolite of the methionine pathway. When methionine is released from dietary protein it condenses with adenosine triphosphate (ATP) to form S-adenosylmethionine (SAM). SAM acts as a methyl donor and homocysteine is formed. Homocysteine can either be remethylated to form methionine or catabolized in the transsulfuration pathway. The remethylation of homocysteine to methionine requires both vitamin B12 and folic acid. When B12 is deficient in the diet, the folic acid becomes trapped in an unusable form as methyltetrahydrofolate. Megaloblastic anemia results. Large doses of folic acid can override the pathway and mask a B12 deficiency.

Homocysteine, Cont'd

- Serum homocysteine will rise when there is a B12 and or a folic acid deficiency.
- The threshold for rising levels of homocysteine appears to be serum folate <12.5 nmol/L and/or serum B12 <225 pmol/L. The etiology of the disease process is unclear. Also, elevated levels of homocysteine are associated with risk for end stage renal failure. Normal levels and "at risk" levels are not consistent in the research literature and remain under research investigation.

Homocysteine, Cont'd

Increased levels of Homocysteine

Associated with:

Renal failure

Folate deficiency

B12 deficiency

CHD

Smoking

Drugs that may increase levels:

Methotrexate

Dilantin

Nitrous oxide

Vitamin K

Deficiency:

- Prolonged prothrombin time
- Small hemorrhagic spots
- Impaired bone formation

Protein C

70% - 140%

- A fibrin inhibitor that prevents clotting from occurring indiscriminately. It is produced by the liver, vitamin K is required for its production. Test is done to evaluate patients with severe thrombosis.
- Values decreased: cirrhosis, vitamin K deficiency, anticoagulant drugs.

Protein S

70%-140%

- A cofactor which enhances the anticoagulant effect of Protein C
- Produced in the liver.
- Vitamin K required for production.

Zinc

- Deficiency is widespread.
- Diuretics can lead to deficiency.
- Elderly subjects have high incidence of deficiency.