

Medical Laboratory Assessment

Arthur Jones, EdD, RRT

This Presentation is Approved for
0.5 CRCE Credit Hour

Learning Objectives

- Recognize normal value ranges for common hematology tests
- Explain the implications of abnormal values from common hematology tests
- Recognize normal value ranges for common blood chemistry tests
- Explain the implications of abnormal values from common blood chemistry tests

Hematology

Complete Blood Count (CBC)

- Hemoglobin: g/dl
- Hematocrit
- RBC count
- WBC count
- Differential count
- Platelet count

FYI see links below for additional information on CBC

Complete Blood Count (CBC)

- Hemoglobin
 - ❖ Normal = 13 - 17 g/dl
 - ❖ Decreased with
 - Hemorrhage
 - Hemodilution
 - Decreased RBC production (anemia)
 - Hemolysis

Complete Blood Count (CBC)

- Hemoglobin
 - ❖ Decreased with
 - Hemorrhage
 - Hemodilution
 - Decreased RBC production (anemia)
 - ❖ Increased with
 - Hemoconcentration: dehydration
 - Polycythemia, e.g. chronic bronchitis

Complete Blood Count (CBC)

- Hematocrit: percentage of formed elements in whole blood
 - ❖ Normal = 40 - 50 Vol%
 - ❖ Decreased with
 - Hemorrhage
 - Anemia
 - Hemodilution

See links below for description of hematocrit measurement

Complete Blood Count (CBC)

- Hematocrit
 - ❖ Estimated as $Hb \times 3$
 - ❖ Elevated Hct → increased blood viscosity
 - ❖ Increased with
 - Hemoconcentration
 - Polycythemia - excessive RBCs
 - Leukemia - excessive WBCs

Complete Blood Count (CBC)

- RBC count
 - ❖ Normal = 4.2 - 5.7 M/mm³
 - ❖ Decreased with
 - Hemorrhage
 - Hemodilution
 - Hemolytic diseases
 - Decreased production - bone marrow or kidney disease
 - Exposure to leeches, vampires, etc.

Complete Blood Count (CBC)

- RBC count
 - ❖ Normal = 4.2 - 5.7 M/mm³
 - ❖ Increased with
 - Polycythemia
 - Hemoconcentration

Complete Blood Count (CBC)

- WBC count: number per mm³
 - ❖ Normal = 4 - 11 k/mm³
 - ❖ Increased with
 - Infection
 - Leukemia

Complete Blood Count (CBC)

- WBC count
 - ❖ Decreased with
 - Immunosuppression - AIDS, CIDS, steroids, cyclosporine
 - Overwhelming infection - WBCs are used up

Complete Blood Count (CBC)

- Differential count: % of each WBC type
 - ❖ Neutrophils: 38 - 80%
 - ❖ Lymphocytes: 15 - 49%
 - ❖ Monocytes: 0 - 13% (alveolar macrophages)
 - ❖ Eosinophils: 0 - 8.0%
 - ❖ Basophils: 0 - 2.0% (mast cells)

See links below to view the WBC types

Complete Blood Count (CBC)

- Differential count
 - ❖ Increased
 - Neutrophils: bacterial infection
 - Lymphocytes: viral infection, e.g. mononucleosis
 - Monocytes: leukemia, viral infections

Complete Blood Count (CBC)

- Differential count
 - ❖ Increased
 - Neutrophils: bacterial infection
 - Lymphocytes: viral infection
 - Monocytes: leukemia, viral infections
 - Eosinophils: allergy, parasitic infection
 - Basophils: lymphoma, viral infections, inflammation

Complete Blood Count (CBC)

- Platelet count
 - ❖ Platelets necessary for coagulation
 - ❖ Normal value = 140 - 390 k/mm³
 - ❖ Decreased with
 - Immune reactions
 - Disseminated intravascular coagulopathy (DIC)
 - Medications: heparin, aspirin

FYI see links below to view platelets

Hematology

- International Normalized Ratio (INR)
 - ❖ Index of coagulation
 - ❖ Derived from prothrombin time - not a separate test
 - ❖ Normal = 1.0
 - ❖ Range for anticoagulation = 2.0 - 3.0
 - ❖ Surgical risk ≥ 4.5

Blood Chemistry

Serum Electrolytes

- Electrolyte balance affects all organ systems
- All nerve transmission & muscular contraction operate by exchange of ions across cell membranes
- Types
 - ❖ Cation - positive charge, e.g. Na⁺
 - ❖ Anion - negative charge, e.g. Cl⁻

Serum Electrolyte - Normals

| <u>Ion</u> | <u>Normal Range</u> |
|-------------------------------|---------------------|
| Na ⁺ | 137 - 147 mEq/dl |
| K ⁺ | 3.5 - 5.0 mEq/dl |
| Ca ⁺⁺ | 8.5 - 10.9 mg/dL |
| Mg ⁺⁺ | 1.8 - 3.0 mg/dL |
| Cl ⁻ | 101 - 111 mmol/L |
| CO ₂ | 20 - 29 mmol/L |
| PO ₄ ⁻⁻ | 2.4 - 4.1 mg/dL |

Serum Electrolyte - Abnormals

| <u>Ion</u> | <u>Decreased: Causes</u> |
|-----------------|--|
| Na ⁺ | Diarrhea, vomiting Renal failure Diabetes Insipidus Inadequate intake |
| | <u>Decreased: Sequelae</u> |
| | Cerebral Edema Confusion, seizures Shock |

Serum Electrolyte - Abnormals

| <u>Ion</u> | <u>Increased: Causes</u> |
|-----------------|--|
| Na ⁺ | H ₂ O loss Excessive intake Renal disease |
| | <u>Increased: Sequelae</u> |
| | Altered mental status Seizures |

Serum Electrolyte - Abnormals

| <u>Ion</u> | <u>Decreased: Causes</u> |
|----------------|---|
| K ⁺ | Alkalemia Mg depletion Diuretics Inadequate intake |
| | <u>Decreased: Sequelae</u> |
| | Tachydysrhythmias Muscle weakness Altered mental status |

Serum Electrolyte - Abnormals

| <u>Ion</u> | <u>Increased: Causes</u> |
|----------------|--------------------------------|
| K ⁺ | Renal failure Tissue damage |
| | <u>Increased: Sequelae</u> |
| | Bradydysrhythmias |

Serum Electrolyte - Abnormals

| <u>Ion</u> | <u>Decreased: Causes</u> |
|------------|--|
| Ca++ | Inadequate intake Cirrhosis Mg depletion Parathyroid dx |
| | <u>Decreased: Sequelae</u> |
| | CHF Seizures |

Serum Electrolyte - Abnormals

| <u>Ion</u> | <u>Increased: Causes</u> |
|------------|---|
| Ca++ | Malignancy Parathyroid dx Excessive intake |
| | <u>Increased: Sequelae</u> |
| | Hyperreflexia Altered mental status Kidney stones |

Serum Electrolyte - Abnormals

| <u>Ion</u> | <u>Decreased: Causes</u> |
|------------|--|
| Mg++ | Hypercalcemia Alcoholism Inadequate intake |
| | <u>Decreased: Sequelae</u> |
| | Torsades des pointes Irritability Tremors, convulsions |

Serum Electrolyte - Abnormals

| <u>Ion</u> | <u>Increased: Causes</u> |
|------------|---|
| Mg++ | Renal failure Excessive intake |
| | <u>Increased: Sequelae</u> |
| | Heart block Hypotension Muscle weakness |

Serum Electrolyte - Abnormals

| <u>Ion</u> | <u>Increased: Causes</u> |
|------------|---|
| Cl- | Renal failure Excessive intake Dehydration |
| | <u>Increased: Sequelae</u> |
| | Cardiac arrest Metabolic acidemia Muscle weakness |

Serum Electrolyte - Abnormals

| <u>Ion</u> | <u>Decreased: Causes</u> |
|------------|--|
| Cl- | K+, Na+ depletion HCO ₃ ⁻ retention |
| | <u>Decreased: Sequelae</u> |
| | Confusion Hypoventilation Paralysis |

Serum Electrolyte - Abnormals

| <u>Ion</u> | <u>Increased: Causes</u> |
|-------------------------------|--|
| HPO ₄ ⁻ | Skeletal dx, fx Renal failure Hypoparathyroidism |
| | <u>Increased: Sequelae</u> |
| | Paresthesia Convulsions Cardiac arrest |

Serum Electrolyte - Abnormals

| <u>Ion</u> | <u>Decreased: Causes</u> |
|-------------------------------|--|
| HPO ₄ ⁻ | K ⁺ , Mg ⁺⁺ depletion Ketoacidemia Renal disease |
| | <u>Decreased: Sequelae</u> |
| | Muscle weakness Bone deformities Weight loss |

Serum Electrolyte - Abnormals

| <u>Ion</u> | <u>Increased: Causes</u> |
|-------------------------------|--|
| HCO ₃ ⁻ | Excessive intake Respiratory acidemia |
| | <u>Increased: Sequelae</u> |
| | Metabolic alkalemia Hypochloremia |

Serum Electrolyte - Abnormals

| <u>Ion</u> | <u>Decreased: Causes</u> |
|-------------------------------|---|
| HCO ₃ ⁻ | Metabolic acidemia Diarrhea Diuretics |
| | <u>Decreased: Sequelae</u> |
| | Metabolic acidemia |

Anion Gap

- Anion gap = $[(Na) - (Cl + HCO_3)]$
- Normal = $[(140) - (100 + 24)] = 16$
- Applications
 - ❖ Determine origin of metabolic acidemia
 - ❖ Determine biochemical severity of metabolic acidemia

FYI see links below for more information on anion gap

Anion Gap

- Anion gap = $[(Na) - (Cl + HCO_3)]$
- Normal = $[(140) - (100 + 24)] = 16$
- Elevated gap → fixed acids
 - ❖ Ketoacidosis
 - ❖ Kidney failure
 - ❖ Lactic acidosis
 - ❖ Ingestion excessive amounts of
 - Aspirin
 - Salicylates
 - Alcohols, e.g. methanol

Anion Gap

- Acidemia with normal anion gap
 - ❖ Gastrointestinal loss of HCO_3^-
 - ❖ Renal loss of HCO_3^-
 - ❖ Ammonium chloride
 - ❖ Hyperalimentation fluids

See links below to view anion gap calculator

Renal Function

- Blood urea nitrogen (BUN)
 - ❖ Normal = 8 - 20 mg/dL
 - ❖ Increased with
 - Kidney dx
 - Liver dx
 - Heart dx

FYI see links below for information on Chem 20

Renal Function

- Creatinine
 - ❖ Normal = 0.8 - 1.4 mg/dL
 - ❖ Increased with
 - Kidney failure
 - Dehydration
 - Eclampsia
 - Muscular dystrophy

Cardiac Enzyme Panel

- Total Creatine Kinase (CK)
 - ❖ Normal = 55 - 170 IU/L
- Creatine Kinase (MB) - more specific for myocardial infarction
 - ❖ Normal = 0 - 7 IU/L

FYI see links below for information on cardiac enzymes

Cardiac Enzyme Panel

- Troponin: gold standard
 - ❖ Serum troponin rises within 4 to 6 hours post-MI
 - ❖ Reach peak 0 to 24 hours
 - ❖ Fall to normal within 10 to 15 days
 - ❖ Levels above 1.5 ng/mL support a diagnosis of heart attack

D-dimer

- Component of blood clot
- Diagnostic for
 - ❖ Deep vein thrombosis (DVT)
 - ❖ Pulmonary embolus
 - ❖ Aortic aneurysm dissection
- Positive d-dimer > 300 ng/mL

FYI see links below for article on D-dimer

Brain Natriuretic Peptide (BNP)

- Secreted by ventricles in response to stretch
- Endogenous vasodilator
- BNP level used to diagnose CHF
- Can predict weaning failure*
- Interpretation of results
 - ❖ BNP < 50 pg/ML ... not CHF
 - ❖ BNP > 150 pg/mL ... CHF

*Chien JY, Lin MS, Huang YC, Chien YF, Yu CJ, Yang PC. Changes in B-type natriuretic peptide improve weaning outcome predicted by spontaneous breathing trial. Crit Care Med. 2008 May;36(5):1421-6.

Liver Enzymes

- SGOT (Serum Glutamic-Oxaloacetic Transaminase - AST)
- SGPT (Serum Glutamic-Pyruvic Transaminase - ALT)
- Alkaline phosphatase
- GGT (Gamma-Glutamyl Transpeptidase)
- LDH (Lactic Acid Dehydrogenase)

Proteins

- Parameters
 - ❖ Albumin
 - ❖ Globulin
 - ❖ Total protein
- Decreased by
 - ❖ Liver dx - the liver synthesizes proteins
 - ❖ Malnutrition
 - ❖ Chronic inflammation

Proteins

- Function in capillary fluid exchange
 - ❖ Exert colloid osmotic pressure
 - ❖ Causes H₂O reentry at venous side of capillary
 - ❖ Depleted proteins → decreased COP → interstitial edema

See links below for illustration & information on capillary fluid exchange

Pancreatic Enzymes

- Increased: pancreatitis, often with ARDS
 - ❖ Serum amylase
 - ❖ Serum lipase

Glucose

- Normal = 60 - 120 mg/dL
 - ❖ Hyperglycemia
 - Caused by diabetes mellitus (DM)
 - May result in ketoacidemia

Glucose

- Normal = 60 - 120 mg/dL
- Hyperglycemia
 - ❖ Caused by diabetes mellitus (DM)
 - ❖ May result in ketoacidemia
- Hypoglycemia: causes
 - ❖ Excessive insulin
 - ❖ Inadequate dietary intake
 - ❖ Excessive exercise

Lipids

- Cholesterol
 - ❖ Normal = 120 - 240 mg/dL
 - ❖ Increased with
 - Atherosclerosis
 - Diabetes
 - Pregnancy
 - ❖ Decreased with
 - Depression
 - Malnutrition

Lipids

- Triglycerides
 - ❖ Normal = 0 - 200 mg/dL
 - ❖ Increased with
 - Atherosclerosis
 - Liver disease
 - Myocardial infarction
 - ❖ Decreased with
 - COPD
 - Malnutrition, malabsorption

Lipids

- Low-density lipoprotein (bad)
 - ❖ Normal = 60 - 130 mg/dL
 - ❖ Increased with - atherosclerosis

Lipids

- High-density lipoprotein (good)
 - ❖ Normal = 35 - 135 mg/dL
 - ❖ High level → healthy metabolism

Summary & Review

- Hematology
 - ❖ CBC
 - ❖ INR
- Blood chemistry
 - ❖ Electrolytes
 - ❖ Renal function
 - ❖ Cardiac, liver, & pancreatic enzymes
 - ❖ Proteins
 - ❖ Glucose
 - ❖ Lipids