Interpreting Chemistry and Hematology for Adult Patients

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Purpose
The purpose of this continuing education module is to provide nurses with the knowledge and skills to understand the effects of changes in common chemistry and complete blood count lab values on the body.

Learning Objectives
After successful completion of this course, you will be able to:

- Identify normal chemistry values for the adult patient
- Define the normal range of laboratory values for components of a complete blood count for the adult patient
- Explain at least two causes and complications of abnormal chemistry values and complete blood count
- Identify at least one treatment associated with abnormal findings
- Discuss reasons why lab values may be either elevated or decreased

Introduction
Using laboratory values can be a key piece of assessment to determine what is occurring within the body of a patient. There are numerous laboratory tests that can be done. The most common tests include chemistry panels, hematology (such as the complete blood count), and blood gases. This course will take a closer look at these components.

This course would not be complete without a review of the bodily fluids and the effect of changes within this system that affect electrolytes, blood counts, and blood gases.

Lab values for this course are taken from the Rush Medical Laboratory (Rush University Medical Center, 2015). Remember that there is some variation in ranges based on the references and machines that each laboratory uses, so be aware of the normal ranges for your facility.

Fluids
Fluid and electrolyte balance is essential to keep the body functioning efficiently. To understand how this balancing act occurs, we need to look at the function of fluid in the body.

Balancing Act
Fluids such as blood, serum, and cerebral spinal fluid work as a transport mechanism for nutrients, gases, and waste products. Every day the body performs a balancing act involving intake and output to maintain the proper amount of fluid. This occurs through:

- Insensible losses
    - Cannot be measured
    - Evaporation is consistent but can be influenced by
        - Body surface area
        - Metabolic rates
        - Environmental changes such as changes in humidity

        - Respiratory rates
- Sensible losses
    - Are measurable – average amount lost daily: 2.6 liters
        - Urination
        - Defecation
        - Wounds
        - Vomiting

What is lost through these mechanisms must be replaced to maintain fluid balance.
(Willis, 2015)

Did You Know?

An average person loses between 150-200 mL/day from defecation. This loss may increase to over 5,000 mL/day with severe diarrhea (Willis, 2015).

Fluid Compartments

Fluid is contained in two distinct compartments divided by cellular walls.

- Intracellular (ICF)- fluid inside the cell
- Extracellular (ECF)- fluid outside the cell
    - Intravascular: fluid within the vascular system/blood stream
    - Interstitial: fluid in the tissues/edema

Fluid moves between the ICF and ECF through semipermeable membranes sometimes bringing solutes. This occurs by

- Diffusion: **solutes** move from an area of higher concentration to an area of lower concentration
- Osmosis: **fluids** move from an area of higher concentration to an area of lower concentration

The purpose of diffusion and osmosis is to equalize the number of positive and negative ions within and outside the cell.
(Willis, 2015)

Test Your Knowledge

You are dehydrated, where are most of the solutes and which type of movement is necessary to regain your fluid balance?

A. **Intravascular and osmosis**
B. Extracellular and diffusion
C. Intracellular and osmosis
D. Intracellular and diffusion

Rationale:

- Extracellular (ECF)- fluid outside the cell
- Intravascular: fluid within the vascular system/blood stream
- Interstitial: fluid in the tissues/edema
- Diffusion: **solutes** move from an area of higher concentration to an area of lower concentration
- Osmosis: **fluids** move from an area of higher concentration to an area of lower concentration

Did you get this right? Remember, dehydration causes the solutes to become more concentrated due to the loss of fluid in the extracellular compartment. To equalize the solutes within and outside the cell, fluid needs to move. Therefore, some of the fluid will move out of the cell to the intravascular space to dilute the solutes.

Metabolic Components

The human body is constantly trying to keep a balance of homeostasis with:

- Fluid:
  - Albumin
  - Blood
- Electrolytes:
  - Calcium
  - Chloride
  - Chloride
  - Magnesium
  - Phosphorous
  - Potassium
  - Sodium
- Other metabolic components
  - Albumin
  - Alkaline Phosphatase
  - ALT/SGPT
  - AST/SGPT
  - Bilirubin
  - Blood Urea Nitrogen
  - Carbon Dioxide
  - Creatinine
  - Glucose
  - Protein

Metabolic Components: Laboratory Testing

The most common way to determine the metabolic component values is to draw either a Basic Metabolic Panel (BMP) or a Complete Metabolic Panel (CMP). However, you will see from the description of each panel, two electrolytes, phosphorous and magnesium, are NOT included. Therefore, these two electrolytes will have to be ordered separately from the panels when indicated (Rush University Medical Center, 2015).

Basic Metabolic Panel (BMP) consists of:

- Calcium
- Carbon dioxide
- Chloride
- Creatinine
- Glucose
- Potassium
- Sodium
- Urea Nitrogen

Complete Metabolic Panel (CMP) consists of:

- All the elements of the BMP and
- Albumin
- Alkaline Phosphatase
- ALT/SGPT
- AST/SGPT
- Bilirubin, total

- Protein

Complete Blood Count

- A differential white blood cell count (diff)
- Hematocrit (Hct)
- Hemoglobin (Hb or Hgb)
- Platelets
- Red blood cell components, such as mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), and mean corpuscular hemoglobin concentration (MCHC)
- Red blood cell count (RBC)
- White blood count (WBC)

Ranges for normal laboratory values vary among age groups, genders, and laboratories. The laboratory references given in this course are from one institution. All healthcare institutions will have a laboratory reference manual for normal ranges available to staff. You should know where to access this material.

Metabolic Compounds: Electrolytes

Electrolytes are chemical compounds that break down into ions, carrying a positive or negative charge. When these are not in balance, pathological changes occur. This module will discuss the following electrolytes:

- Calcium
- Chloride
- Magnesium
- Phosphorous
- Potassium
- Sodium

Electrolyte Review

Electrolyte	Cation (+) Anions (-)	Normal Range	ICF ECF	Functions
Bicarbonate	(-)	22-26 mEq/L	ECF	Regulates acid/base balance
Calcium	(+)	8.7-10.7 mg/dL (total serum Ca) 4.4-5.3 mg/dL (Ionized Ca)	ECF	Blood coagulation Endocrine functions Muscular contraction Nerve excitability
Chloride	(-)	99-108 mEq/L	ECF	Attaches to positive electrolytes Tissue osmolality Transport of carbon dioxide (CO_2) Potassium retention Formation of hydrochloric acid (HCl)
Magnesium	(+)	1.6-2.7 mEq/L	ICF ECF	Cardiac function Neuromuscular function Enzyme activity
Phosphorus	(-)	2.5-4.6 mg/dL	ICF	Neuromuscular function

				Bone development Formation and storage of energy
Potassium	(+)	3.4-5.3 mEq/L	ICF	Cardiac function Central nervous system function Muscle and nerve excitability Tissue osmolality Glycogen use Enzyme activity
Sodium	(+)	137-147 mEq/L	ECF	Acid-base balance Tissue osmolality Water retention Enzyme activity
This table is a compilation by the author based on: Rush University Medical Center, 2015 & Willis, 2015)				

Electrolyte Imbalances

Fluid intake and output, acid-base balance, hormone secretion, and normal cell function all influence electrolyte balance. Because electrolytes function both collaboratively and individually, imbalances in one electrolyte can affect balance in others.

In the previous table, the main compartment that an electrolyte is concentrated in was indicated. However, this does not mean that this is the only compartment that they will be found in. The electrolytes are constantly moving with the fluid to maintain balance and electroneutrality.

Did You Know?

Even though electrolytes exist in the ICF and the ECF, only the amount of electrolytes in the ECF is measured when a lab sample is drawn (Willis, 2015).

Test Your Knowledge

Electrolytes function:

A. Independently
B. ***In balance with other electrolytes***
C. In balance with hormones
D. To influence acid-base balance

Rationale: Fluid intake and output, acid-base balance, hormone secretion, and normal cell function all influence electrolyte balance. Because electrolytes function both collaboratively and individually, imbalances in one electrolyte can affect balance in others.

	High/Hypernatremia			Low/Hyponatremia		
Electrolyte	Value	Causes	Clinical Picture	Value	Causes	Clinical Picture
Sodium	Greater than 145 mEq/L	Diabetes Insipidus Diabetes mellitus Fluid loss Vomiting	Anorexia Nausea Vomiting Dry mucous	Less than 135 mEq/L	Syndrome of Inappropriate Antidiuretic hormone secretion (SIADH)	Diarrhea Nausea Vomiting Tachycardia

		Diarrhea Decreased fluid intake Dehydration High sodium intake Impaired renal function Cushing's syndrome Congestive heart failure	membranes Tachycardia Hypertension Restlessness Agitation Febrile hyperreflexia Tremors Muscle twitching Decrease skin turgor Concentrated urine		Addison's disease Burns Overhydration Metabolic acidosis Water retention Diuretics Low sodium intake Fever	Hypotension Headaches Lethargy Confusion Muscle weakness Pallor Dry mucous membranes Dilute urine

Treatment:

Hypernatremia:

- Fluid resuscitation: Replacement of depleted fluid volume with free water (intravenous and oral solutions without sodium) is based on the severity of the hypernatremia. Sodium should be decreased slowly to avoid rapid movement of water into the brain as the sodium moves out of the cells. When sodium is decreased rapidly cerebral edema and herniation may occur (Lukitsch, 2017)
- Medications: Used to decrease the volume of fluid loss with diabetes insipidus (Willis, 2015)

Hyponatremia:

- Fluid restriction: Used to concentrate the intravascular fluid, resulting in fluid and electrolyte movement to obtain balance and electroneutrality. Extra fluid is excreted by the kidneys
- Diuretic adjustment: Used to increase the amount of fluid excreted by the kidneys, resulting in higher sodium content (Mayo Clinics, 2018)
- Hypertonic saline infusion: Replacement of depleted sodium with hypertonic saline (3% or 5% saline solutions) is based on the severity of the hyponatremia. Sodium should be increased slowly to avoid rapid movement of water out of the brain as sodium moves into the brain. When water is rapidly decreased, brain dehydration may occur with resultant brain injury (Mayo Clinics, 2018; Willis, 2015))

Did You Know?

Sodium levels should not be raised more than 25 mEq/Lin the first 48 hours with the rate not exceeding 1 to 2 mEq/L/hour (Willis, 2015)

	High/Hyperkalemia			Low/Hypokalemia		
Electrolyte	Value	Causes	Clinical Picture	Value	Causes	Clinical Picture
Potassium	Greater than 5 mEq/L	Burns Renal failure Injury response Diabetic Ketoacidosis Metabolic acidosis Increased potassium intake	ECG changes: Tachycardia, Widened QRS Peaked T waves Lengthening of PR	Less than 3.5 mEq/L Severe less than 2.5	Diarrhea Vomiting Gastric Suctioning Diuretics Excessive sweating Refeeding syndrome Malnutrition	ECG changes: Dysrhythmias Shortened ST segment Flattened or inverted T-waves Appearance of "U" wave

		Potassium-sparing diuretics ACE inhibitors Beta-blockers Addison's disease Blood bank products Hemolyzed blood samples (falsely high results)	interval P wave difficult to identify Ventricular fibrillation Decreased urine output Lethargy Decreased muscle tone Muscle cramps	mEq/L	Anorexia Decreased potassium intake Alcoholism Acute renal failure Steroids Stress Insulin Epinephrine Bronchodilators Metabolic alkalosis Cushing's syndrome	Intestinal ileus, gastric dilation Anorexia Vomiting Diarrhea Polyuria Malaise Drowsiness Altered level of consciousness Muscle weakness

Treatment:

Hyperkalemia:

- Kayexalate: Moves the potassium from the area of high concentration (ECF) into a solution that can be excreted by the bowel. Taken orally or rectally, the longer it stays in the system, the more potassium that is removed. Most commonly used when the potassium level is high, but the patient is asymptomatic.
- Calcium administration: Used to decrease the antagonistic effect of potassium excess on the myocardium. Administered intravenously when the potassium level is high, and the patient has cardiac symptoms
- Insulin/glucose drip: Insulin enhances cellular uptake of potassium, forcing it back into cells. Administered intravenously when the potassium level is high, and the patient is symptomatic (Willis, 2015)

Hypokalemia:

- Most cases of hypokalemia can be treated with oral potassium supplements
- Intravenous administration of potassium should only be given in a monitored area, given slowly, and only when necessary due to the risks of high concentrations of potassium being administered and starting a cardiac dysrhythmia
- Use potassium-sparing diuretics

(Willis, 2015)

Note: ***Never administer potassium by I.V. push or bolus; doing so can cause cardiac arrhythmias and cardiac arrest, which could be fatal.***

	High/Hypermagnesemia			Low/Hypomagnesemia		
Electrolyte	Value	Causes	Clinical Picture	Value	Causes	Clinical Picture
Magnesium	Greater than 2.5 mEq/L	Renal failure Renal insufficiency Over-administration of magnesium products (including	Hypotension Respiratory depression Cardiac arrest Drowsiness Weakness Lethargy	Less than 1.5 mEq/L	Chronic Diarrhea Alcoholism Malnutrition or inadequate Mg_2+ intake Malabsorption Increased Ca_2+ intake	Anorexia Nausea Vomiting, Lethargy Weakness, Personality change Tetany (e.g.,

		antacids) Addison's disease Severe dehydration Ketoacidosis	Loss of deep tendon reflexes Paralysis Hypotension Third degree heart block ECG changes: widened QRS complex, prolonged QT interval Flushing		Diuretics Ketoacidosis Acute renal failure Acute myocardial failure Hypokalemia or hypocalcemia Metabolic acidosis Aminoglycosides Digoxin	positive Trousseau or Chvostek sign, spontaneous carpopedal spasm, hyperreflexia) Tremors Seizures

Treatment

Hypermagnesemia:

- Calcium gluconate: Used to reverse magnesium-caused changes, including respiratory depression
- Diuretics: Used to increase magnesium excretion when the kidney function is adequate and fluid balance can be maintained
- Dialysis: Used to remove excess magnesium when the kidney function is poor or non-existent (Lewis, 2018)

Did You Know?

Approximately 70% of magnesium found in the body is NOT bound to protein making magnesium easily removed by dialysis (Lewis, 2018).

Hypomagnesemia:

- Concurrent management of hypokalemia and hypocalcemia is essential
  - Calcium and potassium imbalances are difficult to correct until magnesium is corrected
  - Isolated magnesium sulfate treatment may cause sever hypocalcemia as the sulfates binds ionized calcium
- Magnesium salts (Oral): Used to increase magnesium mild symptomatic or chronic hypomagnesemia
- Magnesium salts (Parenterally): Used to increase magnesium in severe hypomagnesemia or in patients who cannot tolerate oral medications
  (Lewis, 2018a)

Did You Know?

Twice the amount of the estimated magnesium deficit must be given to correct the deficit because 50% of the administered magnesium is excreted by the kidneys (Lewis, 2018a)

	High/Hypercalcemia			Low/Hypocalcemia		
Electrolyte	Value	Causes	Clinical Picture	Value	Causes	Clinical Picture
Calcium	Total: Greater than 10 mg/dL Ionized Greater than 5.3 mg/dL	Over-administration of calcium supplements Renal impairment Thiazide diuretics Bone fractures or prolonged immobility Malignancy Hyperparathyroidism Steroids Hypophosphatemia	ECG changes: diminished ST segment, shortened QT interval, third degree heart block Pathologic fractures Decreased muscle tone Depression Kidney stones	Total: Less than 8.9 mg/dL Ionized: Less than 4.4 mg/dL	Dietary deficiencies of calcium, protein, and/or vitamin D Chronic diarrhea Low albumin Renal failure Hypo-parathyroid Hyperphosphatemia Hyper or Hypo-magnesemia Alkalosis Vitamin D deficiency	Abnormal clotting Tetany, muscle twitches or tremors Muscle cramps Numbness and tingling Irritability, anxiety ECG changes: Prolonged QT interval, lengthened ST segment Fractures

Treatment

Hypercalcemia

- Oral phosphate: Used to bind some of the calcium to prevent absorption
- Saline and loop diuretics: Used to reverse dehydration and keep urine output greater than 250 mL/hour
- Calcitonin or like drugs: Used to decrease bone reabsorption of calcium
- Dialysis: Used in conjunction with other treatments to remove excess calcium
- Parenteral phosphate: Used to bind calcium in life-threatening hypercalcemia

(Lewis, 2018b)

Hypocalcemia

- Oral calcium: Used for post-operative hypoparathyroidism; calcium and vitamin D for chronic hypocalcemia
- Parenteral Calcium gluconate: Used to treat tetany

Lewis, 2018c)

	High/Hyperphosphatemia			Low/Hypophosphatemia		
Electrolyte	Value	Causes	Clinical Picture	Value	Causes	Clinical Picture
Phosphorus	Total: Greater than 2.5 mg/dL or 2.6	Over-administration of phosphorus supplements Hypoparathyroidism Renal	Tachycardia Nausea and diarrhea Abdominal cramps Hyperreflexia	Total: Less than 2.5 mg/dL or 1.8	Ketoacidosis Burns Metabolic alkalosis Respiratory alkalosis Diuretics	Muscle weakness Tremors Bone pain Hyporeflexia Seizures Tissue

	mEq/L	insufficiency Chemotherapy Metabolic acidosis Respiratory acidosis Laxative over-use	Tetany Muscle weakness	mEq/L	Antacids containing aluminum Malnutrition, anorexia Alcoholism Total parenteral nutrition (TPN) Vomiting, diarrhea Malabsorption Hyperparathyroidism	hypoxia Risk of bleeding and infection Weak pulse Hyperventilation Anorexia, dysphagia

Treatment

Hyperphosphatemia:

- Insulin and glucose administration: used to shift phosphorous from the ECF into the ICF
- Phosphate dietary restriction
- Dialysis: may lower phosphorous levels in acute hyperphosphatemia, but in patients with renal failure must be combined with dietary restriction of phosphates
- Saline diuresis: used in patients with intact kidney function to flush excess phosphorous from the system

(Lewis, 2018d)

Hypophosphatemia:

- Oral phosphate replacement
- Parenteral phosphate replacement when:
  - Phosphate level is less than 1 mg/dL
  - Rhabdomyolysis, hemolysis, or neurological symptoms are present

(Lewis, 2018e)

Test Your Knowledge

Which of the following electrolytes can cause cerebral edema if corrected too quickly?

A. Potassium
B. Sodium
C. Magnesium
D. Phosphorus

Rationale: Fluid resuscitation: Replacement of depleted fluid volume with free water (intravenous and oral solutions without sodium) is based on the severity of the hypernatremia. Sodium should be decreased slowly to avoid rapid movement of water into the brain as the sodium moves out of the cells. When sodium is decreased rapidly cerebral edema and herniation may occur (Lukitsch, 2017)

Metabolic Components: Other

In addition to electrolytes, there are other laboratory tests that are included in a complete metabolic panel. These metabolic components can assist in providing additional information about renal and hepatic function.

Metabolic Component Review		
Metabolic Component	Normal Range	Function
Albumin	3.5-5 g/dL	Maintain osmotic pressure Monitor liver function Renal function Nutrition
Alkaline Phosphatase	30-125 unit/L	Enzyme Determining liver function Determining bone disease
Bilirubin	0.2-1.3 mg/dL	Hemoglobin by-product Determining liver function
Blood Urea Nitrogen	8-21 mg/dL	Protein metabolism by-product Determining renal function
Creatinine	0.65-1.2 mg/dL	Determining renal function Determining muscle damage
Glucose • Fasting • Non-fasting	 60-99 mg/dL 60-200 mg/dL	Energy production
Protein	6-8.2 g/dL	Metabolic processes Water homeostasis Immunity
This table is a compilation by the author based on: Rush University Medical Center, 2015 & Willis, 2015)		

Although this table delineates several additional metabolic components, this module will only delve into glucose and albumin.

Glucose

Glucose is a monosaccharide/simple sugar. Glucose, measured from the intravascular space, is the primary source of cellular energy. Excess glucose is stored as glycogen in the liver or muscle tissue. Glucose requires the presence of insulin to move into the cells.

	High/Hyperglycemia			Low/Hypoglycemia		
Metabolic Component	Value	Causes	Clinical Picture	Value	Causes	Clinical Picture
Glucose	Total: Greater than 100mg/dL Fasting or 200mg/dL Non-fasting	Diabetes mellitus Hyperosmolar nonketotic syndrome (HNKS) Cushing's syndrome Extreme stress Excess growth hormone secretion Over-use of	Polydipsia-increased thirst Dehydration Poluria Irritability Headaches, Confusion Decreased level of consciousness Changes in vision Fruity breath	Total: Less than 60 mg/dL non-fasting	Malnutrition Inadequate nutritional intake Exercise Insulin over-use Oral hypoglycemic over-use Liver disease Insulin over-production Beta-blockers Sulfonylureas	Lethargy Unresponsive Confusion Tremors Jitteriness Hunger Pallor Diaphoresis

		glucose Pregnancy (gestational diabetes) Medications- particularly steroids				

Treatment

Hyperglycemia:

- Non-diabetic:
  - Oral intake of free water
  - Increase activity level
  - Decrease glucose intake
- Diabetes with ketones
  - Insulin administration
  - Fluid electrolyte replacement
- Diabetes without ketones
  - Change dietary habits
  - Change or adjust medication dosages

(Mayo Clinic, 2018a)

Hypoglycemia:

- Consumption of 15-20 grams of fast acting carbohydrates
- Glucagon injection for the unresponsive patient
- Glucose infusion for the unresponsive patient

(Mayo Clinic, 2018b)

Serum Albumin

Albumin is a large protein found in the blood plasma that maintains the osmotic pressure between the blood vessels and tissue.

	High/Hyperalbuminemia			Low/Hypoalbuminemia		
Metabolic Component	Value	Causes	Clinical Picture	Value	Causes	Clinical Picture
Albumin	Total: Greater than 4.8 mg/dL	Dehydration Amyloidosis Hepatitis B & C HIV/AIDS Multiple myeloma Impaired kidney disease	Low urine output Weight loss	Total: Less than 3.5 mg/dL	Liver disease Kidney disease Malnutrition Alcoholism	Edema Dry, rough skin, Hair thinning Jaundice Lethargy Cardiac dysrhythmias Weight gain Diarrhea Vomiting

Treatment

Hyperalbuminemia

- Fluid resuscitation

Hypoalbuminemia

- Dietary changes to increase albumin intake
- Immunosuppression medications to lower inflammation that reduces albumin
- Antihypertensive mediations to reduce albumin loss in urine

Test Your Knowledge

Which of the following metabolic components help maintain osmotic pressure?

A. ***Albumin***
B. Glucose
C. Sodium
D. Potassium

Rationale: Albumin is a large protein found in the blood plasma that maintains the osmotic pressure between the blood vessels and tissue.

Metabolic Components: Blood

A typical adult circulates about 5 liters intravascular fluid, which is comprised of:

- 3 liters of plasma
- 2 liters of blood cells
    - White blood cells (leukocytes)
    - Red blood cells (erythrocytes)
    - Platelets (thrombocytes)

Blood Components:
Blood components are measured by a Complete Blood Count (CBC) test. Results from a CBC can be affected by the time of day, hydration, medications, and other blood values.

Metabolic Components: Blood Review		
Component	Normal Range	Function
Hematocrit (HCT)	Male: 42-54% Female: 37-47% Pediatrics: Vary with age	Percentage of RBC in plasma
Hemoglobin (HGB)	Male: 13.5-17.5 g/dL Female: 12-16 g/dL Pediatrics: Vary with age	Transport of oxygen
Mean Corpuscular Hemoglobin (MCH)	26-34 pg Pediatrics: Vary with age	Measurement of the mass of the hemoglobin within the RBC
Mean Corpuscular Hemoglobin Concentration (MCHC)	30-37 gm/dL Pediatrics: Vary with age	Measures how much of each cell is taken up by hemoglobin
Mean Corpuscular Volume (MCV)	82-103 fl Pediatrics: Vary with age	Measurement of the average size of individual red blood cells
Platelets	150-399 $x10^3/mm^3$ Pediatrics: Vary with age	Clotting
Red Blood Cells (RBC)	Male: 4.5-5.9 mil/uL Female: 4-5.2 mil/uL Pediatrics: Vary with age	Carry nutrients and oxygen to the cells
Red Cell Distribution Width (RDW)	11.5-14.5% Pediatrics: Vary with age	Used in conjunction with MCV to determine cause of anemia
White Blood Cells (WBC)	4-10 th/uL Pediatrics: Vary with age	Fight infection

This table is a compilation by the author based on: Rush University Medical Center, 2015 & Willis, 2015)

Red Blood Cells

	High/Polycythemia			Low/Anemia		
Metabolic Component	Value	Causes	Clinical Picture	Value	Causes	Clinical Picture
Red Blood Cells	Very high RBC count	High altitudes Strenuous physical activity Medications, such as gentamicin and methyldopa Smoking Hydration Polycythemia vera COPD Chronic hypoxia	Weakness Headache Fatigue Lightheadedness Shortness of breath Visual disturbances Pruritus Pain in the chest or leg muscles Ruddy complexion Confusion Tinnitus	Total: Less than 3.5 mg/dL	Hemorrhage Destruction of red blood cells Iron deficiency Malnutrition Pernicious or sickle cell anemia Thalassemia Oncology treatments Medications	Fatigue Low energy Weakness Shortness of breath Dizziness Palpitations Pallor Chest pain Tachycardia Hypotension Fainting

Treatment

Polycythemia:

- Fluid Resuscitation: Use of fluids to decrease the volume of circulating RBCs by correcting dehydration
- Phlebotomy: Used to reduce the number of red blood cells by removing blood and replacing it with albumin, plasma, or saline
- Medications; Used to decrease red blood cell production

Anemia:

- Oral medications: Based on the cause of anemia, iron, B12, or medication to increase RBC production may be prescribed
- Blood Transfusions: When severe anemia is present, transfusion of blood products may be necessary to immediately increase blood volume

Hematocrit and Hemoglobin

Hematocrit and hemoglobin are more commonly viewed as indicators of polycythemia and anemia.

- Polycythemia:
  - HCT
    - Male: greater than 52%
    - Female: greater than 48%
  - HGB
    - Male: greater than 18.5 g/dL
    - Female: greater than 16.5 g/dL
- Anemia:
  - HGB
    - Male: less than 13.5 g/dL
    - Female: less than 12 g/dL

(Medterms Medical Dictionary, 2016 & 2016a)

Did You Know?

A hematocrit less than 15% can cause cardiac failure

A hematocrit greater than 60% can cause spontaneous blood clotting

A hemoglobin less than 5 g/dl can cause heart failure

A hemoglobin greater than 20 g/dl can cause hemoconcentration and clotting

MCV, MCH, and MCHC

The MCV, MCH, and MCHC can assist in identification and diagnoses of disease processes.

White Blood Cells

White blood cells (WBC), or leukocytes, are classified into granulocytes (which include neutrophils, eosinophils, and basophils) and agranulocytes (which include lymphocytes and monocytes). WBC are released from the bone marrow and destroyed in the lymphatic system after 14-21 days. Leukocytes fight infection through phagocytosis, where the cells surround and destroy foreign organisms. White blood cells also supply antibodies as part of the body's immune response.

WBC Differential

- The differential consists of the percentage of each of the five types of white blood cells. Normal values for differential are:
- Bands or stabs: 3 - 5 %
- Neutrophils (or segs): 50 - 70% relative value (2500-7000 absolute value)
- Eosinophils: 1 - 3% relative value (100-300 absolute value)
- Basophils: 0.4% - 1% relative value (40-100 absolute value)
- Lymphocytes: 25 - 35% relative value (1700-3500 absolute value)
- Monocytes: 4 - 6% relative value (200-600 absolute value)

	High/Leukocytosis			Low/Leukopenia		
Metabolic Component	Value	Causes	Clinical Picture	Value	Causes	Clinical Picture
White Blood Cells	Greater than 10,000	Trauma Inflammation Acute infection Dehydration Hemo-concentration Cancer Corticosteroids	Fatigue Hepatomegaly Splenomegaly Bleeding Bruising or petechiae	Less than 4,000	Bone marrow disorders Viral infections Severe bacterial infections Cancer Oncology treatment Antibiotics Seizure medications Cardiac medications	Headache Fatigue Fever Bleeding

Did You Know?

A WBC less than 500 places the patient at risk for a fatal infection.

A WBC greater than 30,000 indicates massive infection or serious disease (e.g. leukemia)

Leukopenia/Neutropenia Precautions

Patients with severe leukopenia or neutropenia should be protected from anything that places them at risk for infection. Facilities may have a neutropenic or leukopenic precautions or protocol for these patients. Considerations include:

- Complete isolation
- No injections
- No rectal temperatures or enema

Platelets

Platelets are fragments of cells that are formed in the bone marrow and are vital to blood clotting. Platelets live for approximately nine to 12 days in the bloodstream.

	High/Thrombocytosis			Low/ Thrombocytopenia		
Metabolic Component	Value	Causes	Clinical Picture	Value	Causes	Clinical Picture
Platelets	Greater than 399,000	Injury Inflammatory process Bone marrow disorder Cancer Kidney disease Acute blood loss Infection	Dizziness Headache Chest pain Weakness Neuropathy Vision changes Fainting	Less than 150,000	Disseminated intravascular coagulation (DIC) Immune disorders Suppression of bone marrow	Easy bruising or bleeding Hematuria Bloody bowel movements or emesis Syncope Visual disturbances

Treatment

Thrombocytosis:

- Most causes of thrombocytosis will correct itself when the underlying cause is corrected
- Aspirin: Low dose aspirin will suppress platelet production in the bone marrow

(Mayo Clinic, 2018c)

Thrombocytopenia:

- Most causes of thrombocytosis will correct itself when the underlying cause is corrected
- Blood or platelet transfusion: used to replace loss of blood and platelets
- Splenectomy**:** Used to decrease platelet destruction when nothing else works
- Plasma exchange: Used to treat a life-threatening Thrombotic Thrombocytopenic purpura event

(Mayo Clinic, 2018d)

Did You Know?

A platelet count <20,000 can cause spontaneous bleeding that may result in patient death.

Test Your Knowledge

Your patient has been diagnosed with polycythemia, you anticipate an order for which of the following?

A. Medications used to increase red blood cell production
B. Blood transfusion
C. ***Fluid resuscitation***
D. Fluid restriction

Rationale: Polycythemia Treatment

- Fluid Resuscitation: Use of fluids to decrease the volume of circulating RBCs by correcting dehydration
- Phlebotomy: Used to reduce the number of red blood cells by removing blood and replacing it with albumin, plasma, or saline
- Medications: Used to decrease red blood cell production

Conclusion

As a healthcare provider, it is your responsibility to know where to find your institution's laboratory reference for normal result ranges. While you are not expected to memorize the plethora of laboratory results, it is important to recognize and understand what a high or low result for common tests may mean to your patient.

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