Blood Chemistry Analysis

2011 Georgia Office of EMS Updates

EMT-Paramedic to Paramedic Provider Update

Overview

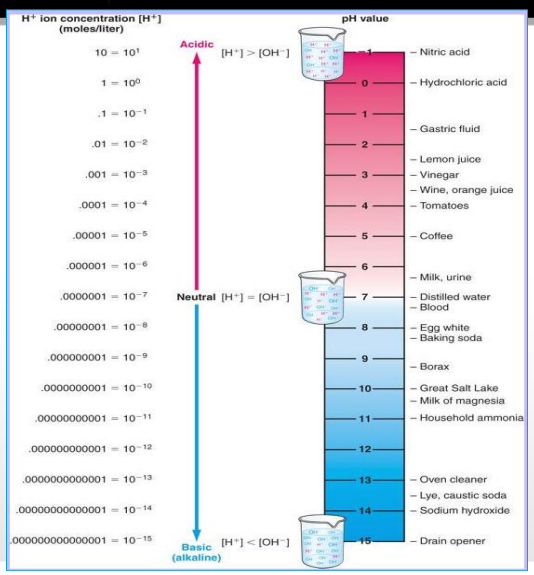
- Blood Gas Analysis and Regulation
- Blood Chemistry
  - Normal values
  - Treatment for some of the more critical abnormal values
- Hematology

BLOOD GAS ANALYSIS

EMT-Paramedic to Paramedic Provider Update

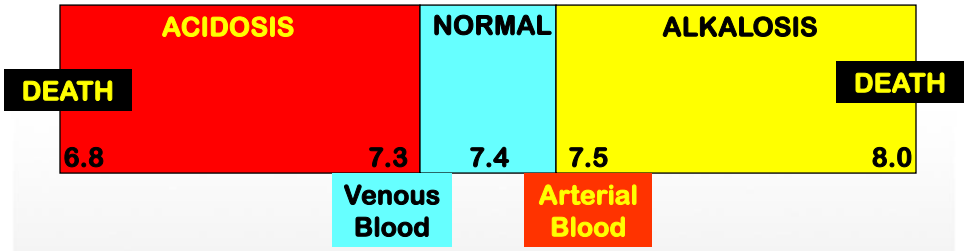
Blood Gas Values

- pH
- PCO_2
- HCO_3
- PO_2
- Base Excess



Blood Gas Values

- pH: Hydrogen ion concentration
  - Normal pH is between 7.35 and 7.45



Change in pH of 0.4 in either direction may result in death!

Blood Gas Values

- PCO_2
  - Normal 35-45mmHg
    - Increased PCO2
      - Respiratory Acidosis
      - Compensated metabolic alkalosis
    - Decreased PCO2
      - Respiratory Alkalosis
      - Compensated metabolic acidosis
- HCO_3
  - Normal 22-26 mEq/L

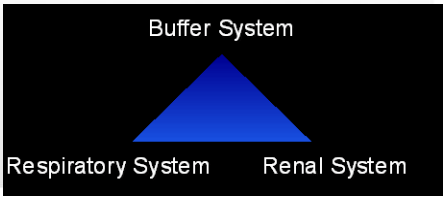
Blood Gases

- Base Excess or Base Deficit
  - Normal -2 to +2 mEq/L
  - Base excess indicates too much buffer (metabolic alkalosis)
  - Base deficit indicates too little buffer (metabolic acidosis)

Acid-Base Regulation

- Maintenance of an acceptable pH range in accomplished by **three** mechanisms:
  - **1) Chemical Buffers**
    - React very rapidly (less than a second)

      $CO_2 + H_2O \quad H_2CO_3 \quad H^+ + HCO_3^-$
  - **2) Respiratory Regulation**
    - Reacts rapidly (seconds to minutes)
  - **3) Renal Regulation**
    - Reacts slowly (minutes to hours)



Acid-Base Imbalance

- **Metabolic acidosis**
  - Accumulation of abnormal acids in blood, low pH
  - Compensatory respiratory alkalosis
- **Metabolic alkalosis**
  - Excess metabolic base or loss of normal acid, high pH
  - Compensatory respiratory acidosis
- **Respiratory acidosis**
  - CO_2 retention leads to increased PCO_2
  - Hypoventilation or intrinsic lung diseases
- **Respiratory alkalosis**
  - Blowing off CO_2 results in decreased PCO_2
  - Hyperventilation
  - Potentially serious diseases may be responsible for high ventilatory levels.

ABG Interpretation

- Check the pH
  - Is the pH normal, acidic, or basic?
- Check the pH
  - High PCO2 indicates respiratory acidosis in the presence of a low pH
  - Low PCO2 indicates respiratory alkalosis in the presence of a high pH
- Check the pH
  - High HCO3 indicates metabolic alkalosis in the presence of a high pH
  - Low HCO3 indicates metabolic acidosis in the presence of a low pH

Blood Gas Analysis: Examples

- Normal pH=7.35-7.45 CO2=35 to 45 HCO3=22 to 26 BE= -2 to +3

1) pH=7.56 CO2=20 HCO3=22 BE -2

2) pH=7.24 CO2=60 HCO3=25 BE +2

3) pH=7.55 CO2=40 HCO3=38 BE +15

4) pH=7.12 CO2=40 HCO3=15 BE -20

1) pH= 7.56 CO2=20 HCO3=22 BE -2

- What do we know about the blood gas?
- pH is increased meaning the patient is alkalotic
- CO2 is decreased meaning the patient is having some type respiratory problem
- HCO3 is normal
- BE is normal
- **The patient is in Respiratory Alkalosis**

2) pH=7.24 CO2=60 HCO3=25 BE +2

- What is wrong with this patient from their gas?
- pH is decreased meaning the patient is acidotic
- CO2 is elevated meaning the patient is having some type respiratory issue
- HCO3 is normal
- BE is in the normal range
- **The patient is in Respiratory Acidosis**

3) pH=7.55 CO2=40 HCO3=38 BE +15

- pH is elevated telling us the patient is alkalotic
- CO2 is in the normal range
- HCO3 is elevated beyond the normal range
- BE is elevated as well
- **The patient is in Metabolic Alkalosis**

4) pH=7.12 CO2=40 HCO3=15 BE -20

- Final Blood Gas Example
- pH is decreased meaning the patient is acidotic
- CO2 is in the normal range
- HCO3 is decreased showing some type metabolic problem
- BE is decreased as well
- **The patient is in Metabolic Acidosis.**

BLOOD CHEMISTRY ANALYSIS

Blood Chemistry (Basics)

- Sodium (Na+)
- Potassium (K+)
- Chloride (Cl-)
- Bicarb (HCO3-)
- Blood Urea Nitrogen (BUN)
- Creatinine (Cr)
- Glucose (BGL)
- Calcium (Ca+)

Blood Chemistry : Na+

- Sodium
  - Normal range 135-145mEq/L
  - Life threatening
    - < 120
    - >155
  - Can cause seizures, venous sinus thrombosis, CNS hemorrhage,

Blood Chemistry: Na+

- Hyponatremia
  - Excessive H2O
  - Cirrhosis, CHF
  - Hypoalbuminemia
    - Nephrotic
    - Malnutrition
  - Vomiting/ Diarrhea
  - Diuretics
  - SIADH
  - Cerebral Salt Wasting
- False Hyponatremia
  - Hyperglycemia
  - Hyperlipidemia

Blood Chemistry: Na+

- Hypernatremia
  - Diabetes Insipidus
  - Diarrhea
  - Dehydration
  - Hypercalciuria
  - Diabetes
  - Hyperaldosteronism

Blood Chemistry: Na+

- Treatment is based partially on the causes
- Do not correct Na+ faster than 10-15 mEq per day
  - will increase risk of cerebral edema
  - 3-4 ml/kg of free water will decrease serum Na+ 1mEq/L
- For acute symptomatic hyponatremia may use hypertonic saline 5-10 ml/kg

Blood Chemistry: K+

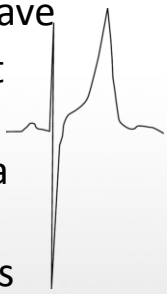
- Potassium
  - Normal 3.5 – 4 mEq/L
  - Life threatening
    - < 2.5
    - >6.5
  - Major complications
    - Arrhythmia
    - weakness

Blood Chemistry: K+

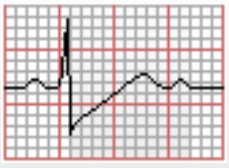
- Hypokalemia
  - Diuretics
  - Hypomagnesium
  - Licorice
  - RTA
  - V/D
  - Pyloric Stenosis
  - DKA
  - Antibiotics (ie: AmphoB)
- Hyperkalemia
  - Acidosis
  - Renal Failure
  - Muscle necrosis
  - Blood Transfusions
  - Hemolysis
  - CAH

Blood Chemistry: K+

- Hyperkalemia
  - Peaked T waves
  - Widening of QRS
  - Loss of P wave
  - ST segment depression
  - Bradycardia
  - Ventricular arrhythmias



- Hypokalemia
  - Prominent U wave
  - ST segment depression
  - Ventricular arrhythmias



Blood Chemistry: K+

- Treatment of Hypokalemia:
  - KCL bolus
    - 0.3 - 1 mEq / kg
    - no more than 0.6 mEq/kg/hour
- Treatment of Hyperkalemia:
  - Calcium chloride
  - Insulin and Glucose
  - NaHCO3
  - Kayexalate
  - Lasix
  - Albuterol

Blood Chemistry: Cl -

- Chloride
  - Normal 95-105 mEq/L
  - Hypochloremia
    - Metabolic Alkalosis
    - Respiratory Acidosis
    - CHF
    - Burns
  - Hyperchloremia
    - Metabolic Acidosis
    - Respiratory Alkalosis
    - Dehydration
    - RTA

Blood Chemistry: HCO3-

- Bicarbonate
  - Normal: 20-26 mEq/L
    - Increased in Metabolic Alkalosis and Compensated Respiratory Acidosis
    - Decreased in Metabolic Acidosis and Compensated Respiratory Alkalosis

Blood Chemistry: BUN

- Blood Urea Nitrogen
  - Normal: 5-20 mg/dl
  - Elevated Tissue Necrosis
    - Gi Bleed
    - High Protein Diet
    - Steroids
    - Shock
    - Dehydration
    - Diarrhea
    - Burns
    - Tissue Necrosis
  - Decreased
    - Anabolic Steroids
    - Hepatic Disease
    - Malnutrition
    - Pregnancy

Blood Chemistry: Cr

- Creatinine
  - Normal: 0.5 – 1.5 mg/dl
  - Increased:
    - Renal disease
    - Muscle necrosis
    - Hypovolemia

Blood Chemistry: Glucose

- Glucose
  - Normal: 60-115mg/dl (infants >40)
  - Hyperglycemia (AMS, Kussmal breathing)
    - Diabetes
    - Cushing's disease
    - Drugs (ie: Steroids, Epi)
    - Pancreatitis
    - Pheochromocytoma
  - Hypoglycemia (Tremors, Seizure, Sweating)
    - Malaria
    - Enzyme deficiency
    - Malignancy
    - Malnutrition
    - Hepatic disease

Blood Chemistry: Glucose

- Treatment of Hypoglycemia
  - Neonate or Infant:
    - 2 ml/kg of a10% Dextrose solution
  - Toddler or Child:
    - 2 ml/kg of a 25% Dextrose solution
  - Adult:
    - 50% Dextrose solution

Blood Chemistry: Glucose

- Treatment of Hyperglycemia
  - Isotonic fluid bolus
  - insulin (*hospital use only*)
  - NaHCO3 if cardiac instability is present

Blood Chemistry: Ca+

- Calcium
  - Normal 8-11mg/dl
  - Critical Values:<7 or > 12 (tetany, seizure, arrhythmia)
- Hypercalcemia (CHIMPS)
  - **C**ancer
  - **H**yperthyroid
  - **I**atrogens
  - **M**ultiple Myeloma
  - **P**rimary Hyperparathyroid
  - **S**arcoidosis

Blood Chemistry: Ca+

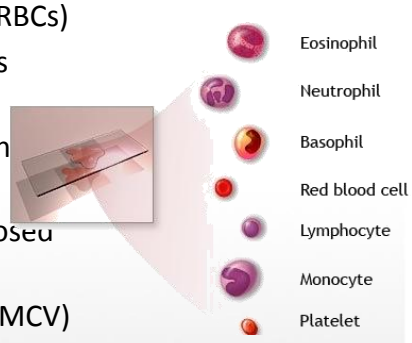
- Hypocalcemia
  - renal failure
  - hypoparathyroid
  - pseudohypoparathyroid
  - magnesium deficiency
  - anticonvulsants
  - Rickets
  - Pancreatitis
  - Blood transfusions

HEMATOLOGY

EMT-Paramedic to Paramedic Provider Update

Complete Blood Count (CBC)

- CBC measures the following:
  - The number of red blood cells (RBCs)
  - The number of white blood cells (WBCs)
  - The total amount of hemoglobin in the blood
  - The fraction of the blood composed of red blood cells (hematocrit)
  - The mean corpuscular volume (MCV) — the size of the red blood cells



CBC: WBCs

TEST	NORMAL VALUES
Leukocyte (White Blood Cell)	X1000 cells/mm³ (μL)
Birth	9.0-30.0
24 hours	9.4-34.0
1 month	5.0-19.5
1-3 years	6.0-17.5
4-7 years	5.5-15.5
8-13 years	4.5-13.5
Adult	4.5-11.0
Neutrophils	
Band form	3-5%
Segmented	54-62%
Lymphocytes	25-33%
Monocytes	3-7%
Eosinophils	1-3%
Basophils	0-0.75%

CBC: RBCs

Erythrocytes (Red Blood Cells)

Cord	3.9-5.5 million/mm³
1-3 days	4.0-6.6 million/mm³
1 week	3.9-6.3 million/mm³
2 weeks	3.6-6.2 million/mm³
1 month	3.0-5.4 million/mm³
2 months	2.7-4.9 million/mm³
3-6 months	3.1-4.5 million/mm³
0.5-2 years	3.7-5.3 million/mm³
2-6 years	3.9-5.3 million/mm³
6-12 years	4.0-5.2 million/mm³
12-18 years (male)	4.5-5.3 million/mm³
12-18 years (female)	4.1-5.1 million/mm³

CBC: Hemoglobin / Hematocrit

Hemoglobin	
1-3 days	14.5-22.5 g/dL
2 months	9.0-14.0 g/dL
6-12 years	11.5-15.5 g/dL
12-18 years (male)	13.0-16.0 g/dL
12-18 (female)	12.0-16.0g/dL

Hematocrit	
1 day	48-69%
2 days	48-75%
3 days	44-72%
2 months	28-42%
6-12 years	35-45%
12-18 years (male)	37-49%
12-18 years (female)	36-46%

CBC: Platelets

Platelet Count	
Birth-1 week	84,000-478,000/mm^3
Thereafter	150,000-400,000/mm^3

Summary

- It is important for paramedics to gain a basic understanding of laboratory analysis.
- As the paramedic role evolves, interpreting blood analysis will become more a part of our everyday practice.