Blood Chemistry Analysis

2011 Georgia Office of EMS Updates

Overview

• Blood Gas Analysis and Regulation
• Blood Chemistry
  – Normal values
  – Treatment for some of the more critical abnormal values
• Hematology
BLOOD GAS ANALYSIS

Blood Gas Values

- pH
- PCO₂
- HCO₃
- PO₂
- Base Excess
Blood Gas Values

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

<table>
<thead>
<tr>
<th>Venous Blood</th>
<th>Arterial Blood</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ACIDOSIS</strong></td>
<td><strong>NORMAL</strong></td>
</tr>
<tr>
<td>6.8</td>
<td>7.4</td>
</tr>
<tr>
<td><strong>DEATH</strong></td>
<td><strong>ALKALOSIS</strong></td>
</tr>
<tr>
<td>7.3</td>
<td>7.5</td>
</tr>
</tbody>
</table>
  | DEATH        | 8.0

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

Blood Gas Values

- **PCO₂**
  - Normal 35-45mmHg
    - Increased PCO₂
      - Respiratory Acidosis
      - Compensated metabolic alkalosis
    - Decreased PCO₂
      - Respiratory Alkalosis
      - Compensated metabolic acidosis

- **HCO₃**
  - 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)
    \[ \text{CO}_2 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{CO}_3 \rightarrow \text{H}^+ + \text{HCO}_3^- \]
  – 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 PCO\(_2\) indicates respiratory acidosis in the presence of a low pH
  - Low PCO\(_2\) indicates respiratory alkalosis in the presence of a high pH

- Check the pH
  - High HCO\(_3\) indicates metabolic alkalosis in the presence of a high pH
  - Low HCO\(_3\) 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
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 (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: AmphiB)

- **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
    • Pregnancy
Blood Chemistry: Cr

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

Blood Chemistry: Glucose

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

• Treatment of Hypoglycemia
  – Neonate or Infant:
    • 2 ml/kg of a 10% 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)
  – Cancer
  – Hyperthyroid
  – Iatrogens
  – Multiple Myeloma
  – Primary Hyperparathyroid
  – Sarcoidosis

Blood Chemistry: Ca+

• Hypocalcemia
  – renal failure
  – hypoparathyroid
  – pseudohypoparathyroid
  – magnesium deficiency
  – anticonvulsants
  – Rickets
  – Pancreatitis
  – Blood transfusions
HEMATOLOGY

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

<table>
<thead>
<tr>
<th>TEST</th>
<th>NORMAL VALUES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leukocyte (White Blood Cell) $\times 10^9$ cells/mm³ $\times 1000$ cells/µL</td>
<td></td>
</tr>
<tr>
<td>Birth</td>
<td>9.0-30.0</td>
</tr>
<tr>
<td>24 hours</td>
<td>9.4-34.0</td>
</tr>
<tr>
<td>1 month</td>
<td>5.0-19.5</td>
</tr>
<tr>
<td>1-3 years</td>
<td>6.0-17.5</td>
</tr>
<tr>
<td>4-7 years</td>
<td>5.5-15.5</td>
</tr>
<tr>
<td>8-13 years</td>
<td>4.5-13.5</td>
</tr>
<tr>
<td>Adult</td>
<td>4.5-11.0</td>
</tr>
<tr>
<td>Neutrophils</td>
<td></td>
</tr>
<tr>
<td>Band form</td>
<td>3-5%</td>
</tr>
<tr>
<td>Segmented</td>
<td>54-62%</td>
</tr>
<tr>
<td>Lymphocytes</td>
<td>25-33%</td>
</tr>
<tr>
<td>Monocytes</td>
<td>3-7%</td>
</tr>
<tr>
<td>Eosinophils</td>
<td>1-3%</td>
</tr>
<tr>
<td>Basophils</td>
<td>0-0.75%</td>
</tr>
</tbody>
</table>

## CBC: RBCs

<table>
<thead>
<tr>
<th>Erythrocytes (Red Blood Cells)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Cord</td>
<td>3.9-5.5 million/mm³</td>
</tr>
<tr>
<td>1-3 days</td>
<td>4.0-6.6 million/mm³</td>
</tr>
<tr>
<td>1 week</td>
<td>3.9-6.3 million/mm³</td>
</tr>
<tr>
<td>2 weeks</td>
<td>3.6-6.2 million/mm³</td>
</tr>
<tr>
<td>1 month</td>
<td>3.0-5.4 million/mm³</td>
</tr>
<tr>
<td>2 months</td>
<td>2.7-4.9 million/mm³</td>
</tr>
<tr>
<td>3-6 months</td>
<td>3.1-4.5 million/mm³</td>
</tr>
<tr>
<td>0.5-2 years</td>
<td>3.7-5.3 million/mm³</td>
</tr>
<tr>
<td>2-6 years</td>
<td>3.9-5.3 million/mm³</td>
</tr>
<tr>
<td>6-12 years</td>
<td>4.0-5.2 million/mm³</td>
</tr>
<tr>
<td>12-18 years (male)</td>
<td>4.5-5.3 million/mm³</td>
</tr>
<tr>
<td>12-18 years (female)</td>
<td>4.1-5.1 million/mm³</td>
</tr>
</tbody>
</table>
### 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 years (female): 12.0-16.0 g/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/mm³
- Thereafter: 150,000-400,000/mm³
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.