BEEBE HEALTHCARE
MARGARET H. ROLLINS SCHOOL OF NURSING
BASIC CONCEPTS OF ACID BASE BALANCE
(Respiratory Acidosis & Alkalosis)

ACID – substance that can donate a hydrogen ion to a solution

Strong – hydrochloric acid

Weak – carbonic acid – $H_2CO_3 \rightarrow CO_2 + H_2O$

CO_2

- Regulated by lungs
- Represents carbonic acid level in the body
- Normal value – 35 to 45 mmHg

- Nonvolatile Acids (fixed acids)
  - By-products of protein, fat, and carbohydrate metabolism
  - Excreted by kidneys

BASE – a substance that can accept Hydrogen ions

- Bicarbonate (HCO_3) $HCO_3 + H^+ = H_2CO_3$
  - Represents bicarbonate level in body
  - Regulated by kidneys

    $HCO_3 + H^+ \rightarrow H_2CO_2 \rightarrow CO_2 + H_2O$
  - Normal value – 22 to 26 mEq/L

pH – represents the concentration of Hydrogen ions present in a solution

- Hydrogen ion concentration
  - Lower – more alkaline solution causes increased pH
  - Higher – more acid solution causes decreased pH
  - Normal value – 7.35 to 7.45

- Blood pH
  - Acidemia pH < 7.35
  - Alkalemia pH > 7.45
  - Euphemia pH normal 7.35 – 7.45

    if < 7.20 >7.55 requires immediate treatment

    < 6.8 >7.8 incompatible with life
- Acidosis pH
  - Acid content increased
  - Base content decreased
- Alkalosis pH
  - Acid content decreased
  - Base content increased

ANION GAP = $(Na + K) – (Cl + CO_2)$

- Helps determine if situation is metabolic alkalosis or metabolic acidosis
- Decreased < 10 mEq/L: indicates metabolic alkalosis from bicarbonate retention (nephrosis, diuretics)
- Increased > 17mEq/L: indicates metabolic acidosis from increased acid production (diabetic ketoacidosis, starvation, renal failure, loop diuretics)

Regulation of acids and bases occurs with 3 compensatory mechanisms:

1. Chemical buffers
2. Respiratory (lungs)
3. Renal (kidneys)

REGULATION

- Chemical Buffers
  - Bicarbonate
  - Organic phosphates
  - Proteins

- Respiratory Regulation
  - Regulate CO2 level through rate and depth of respiration
  - "Blow Off" excess CO2
  - Retain CO2
  - 50-75% effective
  - Occurs in 1-3 minutes

- Renal Regulation
  - Bicarbonate level
  - Retain bicarbonate
    - Secrete hydrogen
    - Reabsorb bicarbonate
    - Generate bicarbonate
- Excrete bicarbonate

ABG NORMAL RANGES

- pH: 7.35 – 7.45
- PaCO2: 35 – 45 mmHg
- HCO3: 22 – 26 mEq/L
- Oxygen
  PaO2: 80 - 100 mmHg
  SaO2: ≥ 96%

ACID BASE DISTURBANCE

- Respiratory
  - Acidosis
  - Alkalosis
- Metabolic
  - Acidosis
  - Alkalosis

ABG'S

- Components
  - pH – ratio of acid to base
  - CO2 – lungs
  - HCO3 – kidneys
- Compensatory mechanisms responsible for maintaining normal pH
  - Chemical buffers

- Respiratory regulation
- Renal regulation

RESPIRATORY ACIDOSIS

PATHOPHYSIOLOGY

- Increased PaCO2 > 45mmHg (hypercapnea)
- Decreased pH < 7.35
- Hypoventilation
- Inadequate diffusion of gases

COMPENSATORY MECHANISMS

- Chemical buffering system
  - Increased production of bicarbonate ions
- Renal System
  - Reabsorbs and generates bicarbonate
  - Increases secretion of hydrogen ions
  - Compensates slowly > 24h

3 STAGES OF COMPENSATION

1. Acute respiratory acidosis
   - No sign of compensation
   - Bicarbonate WNL
   - PaCO2 level increased
   - pH decreased < 7.35
   - Example

     pH = 7.33
     $PaCO_2$ = 62
     HCO_3 = 26
2. Partially compensated respiratory acidosis
   - pH decreased
   - PaCO2 elevated
   - HCO3 elevated (sign of compensation)
   - Example

     pH = 7.33
     $PaCO_2$ = 62
     HCO_3 = 28

3. Fully compensated respiratory acidosis
   - pH – low, normal level
   - PaCO2 - elevated
   - HCO_3 – (Bicarbonate) - elevated to compensate
   - Example

     pH = 7.35
     $PaCO_2$ = 62
     HCO_3 = 30

CAUSES OF RESPIRATORY ACIDOSIS

- Alveolar hypoventilation
  - Healthy lungs

        - CNS depression anesthesia, sedatives, narcotics, tumor, stroke
        - Neuromuscular disease (polio, myasthenia gravis, Guillain-Barre syndrome
        - Trauma (chest pain, spinal cord injury, brain injury, chest wall damage)
        - Severe thoracic restrictive disorders - kyphosis, scoliosis, Pickwickian syndrome (caused by obesity)
    - Abnormal or diseased lungs
        - COPD
        - Acute airway obstruction

SIGNS OF RESPIRATORY ACIDOSIS

- pH < 7.35
- PaCO2 > 45mmHg
- Hypoxemia
- Hyperkalemia
- Cardiac dysrhythmias

SYMPTOMS

- Hypotension
- Warm flushed skin
- Dizziness
- Headache (caused by vasodilation of vessels)
- Drowsiness
- Disorientation
- Coma
- Seizures
- Hypoventilation
- Dyspnea (two or three word phrases)
- Tachypnea with shallow respirations

CLINICAL INTERVENTIONS

- Monitor/Assess
    - Cardiac rhythm
    - Electrolytes (increased K)
    - ABG's
    - Pulse oximetry
    - Nutritional and hydration status
    - Altered LOC
    - Altered thought processes
- Nursing Diagnosis
    - Impaired gas exchange
    - Ineffective airway clearance
    - Ineffective breathing pattern

TREATMENT

- Treat underlying cause
- Decrease CO_2 retention
- Mechanical ventilation
- Correct electrolyte imbalance

REVIEW

- PaCO2 increased
- pH decreased
- Cause - alveolar hypoventilation
- Renal system increases HCO3 to compensate

RESPIRATORY ALKALOSIS

PATHOPHYSIOLOGY

- Decreased PaCO2 < 35mmHg hypocapnea
- Increased pH > 7.45
- Alveolar hyperventilation – excessive loss of CO2

COMPENSATORY MECHANISMS

- Chemical buffering system
  - Decreases production of bicarbonate ions
- Renal System
  - Decreased reabsorption of bicarbonate
  - Secretes excess bicarbonate in the urine
  - Reduces secretion of hydrogen ions
  - Compensates slowly > 24h

3 STAGES OF COMPENSATION

1. Acute respiratory alkalosis
   - No signs of compensation
   - HCO3 - WNL (kidney has not compensated for decreased PaCO2)
   - PaCO2 - decreased
   - pH - elevated
   - Example
     pH = 7.47
     $PaCO_2$ = 32
     HCO_3 = 24
2. Partially compensated respiratory alkalosis
   - pH elevated
   - PaCO2 decreased
   - Bicarbonate decreased (sign of compensation)
   - Example
     pH = 7.47
     $PaCO_2$ = 32
     HCO_3 = 20
3. Fully compensated respiratory alkalosis
   - pH – high, normal level
   - PaCO2 - decreased
   - HCO3 - decreased to compensate
   - Example
     pH = 7.45
     $PaCO_2$ = 32
     HCO_3 = 18

CAUSES – alveolar hyperventilation (or blowing off CO2)

- Normal healthy lungs

        - Anxiety
        - Pain
        - Fever
        - Stimulant drugs
        - CNS lesions
        - Head trauma
        - Sepsis
        - Mechanical ventilation
        - High altitude
    - Abnormal or diseased lungs
        - Acute asthma
        - Pneumonia
        - Pulmonary edema
        - Pulmonary embolism
        - Pulmonary vascular disease

SIGNS

- pH > 7.45
- CO2 < 35mmHg
- Hypokalemia
- Hypocalcemia
- Cardiac dysrhythmias

SYMPTOMS

- Hyperventilation
- Tachypnea
- Hyperpnea
- Confusion
- Lethargy
- Light-headedness
- Tachycardia
- Dysrhythmias
- Numbness
- Tingling of extremities
- Tetany
- Seizures
- Nausea/vomiting

CLINICAL INTERVENTIONS

- Monitor/Assess
    - Cardiac rhythm
    - Electrolytes
    - ABG’s
    - Pulse oximetry
    - Altered LOC
- Nursing Diagnosis
    - Ineffective breathing pattern
    - Anxiety
    - Acute pain

TREATMENT

- Treat underlying cause
- Increase PaCO2
  - Decrease minute ventilation with mechanical ventilation
- Decrease hyperventilation
  - Re-breathe exhaled CO2 in a paper bag
  - Sedation
  - Pain medication
  - Provide emotional support

REVIEW

- Decreased PaCO2
- Increased pH
- Renal system decreases HCO3 to compensate

Adapted From: A Critical Care System: Arterial Blood Gases: Interpretation and Management by Linda Desmond, Ed.D., RN, CCRN, President of Educational Interactive Solutions, Inc. She is a graduate of Beebe School of Nursing.

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