

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 – $\text{H}_2\text{CO}_3 \rightarrow \text{CO}_2 + \text{H}_2\text{O}$

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) $\text{HCO}_3 + \text{H}^+ = \text{H}_2\text{CO}_3$
 - Represents bicarbonate level in body
 - Regulated by kidneys
- $\text{HCO}_3 + \text{H}^+ \rightarrow \text{H}_2\text{CO}_3 \rightarrow \text{CO}_2 + \text{H}_2\text{O}$
- 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 $\text{pH} < 7.35$
 - Alkalemia $\text{pH} > 7.45$
 - 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 = $(\text{Na} + \text{K}) - (\text{Cl} + \text{CO}_2)$

- Helps determine if situation is metabolic alkalosis or metabolic acidosis
- Decreased < 10 mEq/L: indicates metabolic alkalosis from bicarbonate retention (nephrosis, diuretics)
- Increased > 17 mEq/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 $\text{PaCO}_2 > 45\text{mmHg}$ (hypercapnea)
- Decreased $\text{pH} < 7.35$
- 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 $> 24\text{h}$

3 STAGES OF COMPENSATION

1. Acute respiratory acidosis
 - No sign of compensation
 - Bicarbonate WNL
 - PaCO_2 level increased
 - pH decreased < 7.35
 - Example
 - $\text{pH} = 7.33$
 - $\text{PaCO}_2 = 62$
 - $\text{HCO}_3 = 26$
2. Partially compensated respiratory acidosis
 - pH decreased
 - PaCO_2 elevated
 - HCO_3 elevated (sign of compensation)
 - Example
 - $\text{pH} = 7.33$
 - $\text{PaCO}_2 = 62$
 - $\text{HCO}_3 = 28$
3. Fully compensated respiratory acidosis
 - pH – low, normal level
 - PaCO_2 - elevated
 - HCO_3 – (Bicarbonate) - elevated to compensate
 - Example
 - $\text{pH} = 7.35$
 - $\text{PaCO}_2 = 62$
 - $\text{HCO}_3 = 30$

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 CO₂ 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
 - PaCO₂ = 32
 - HCO₃ = 24
2. Partially compensated respiratory alkalosis
 - pH elevated
 - PaCO₂ decreased
 - Bicarbonate decreased (sign of compensation)
 - Example
 - pH = 7.47
 - PaCO₂ = 32
 - HCO₃ = 20
3. Fully compensated respiratory alkalosis
 - pH – high, normal level
 - PaCO₂ - decreased
 - HCO₃ - decreased to compensate
 - Example
 - pH = 7.45
 - PaCO₂ = 32
 - HCO₃ = 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.

References:

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