NMNEC Concept: **Acid-Base Balance**

Mega Concept: Health and Illness

Category: Homeostasis & Regulation

Concept Name: Acid-Base Balance

Concept Definition:
Factors that affect the regulation of pH and conditions that contribute to imbalances.

Scope and Categories:

- **Scope**: Ranges on a continuum: Acidotic (pH less than 7.35) to optimal balance (maintained by compensatory mechanisms) to alkalotic (pH greater than 7.45)
- **Categories**
    - Respiratory etiologies and processes
    - Metabolic etiologies and processes

Risk Factors:
Acid-base imbalances can affect all individuals regardless of age, gender, race, or socioeconomic status and usually occur as a consequence of an underlying condition or a disease process.

Individual risk factors that result in failure of compensatory mechanisms:

- Underlying conditions: Diabetes, chronic respiratory conditions, renal failure, pain, anxiety, and hypoperfusion states are a few examples.
- Nutrition: Starvation, malnutrition, malabsorption syndrome.
- Smoking: Structural changes including changes from chronic obstructive pulmonary disease (COPD), chronic bronchitis, or asthma.
- Infection: Systemic inflammatory Response Syndrome (SIRS) and Sepsis.
- Complications of treatments: medications, NG suction, and mechanical ventilation.

Physiological Processes and Consequences:

- **Physiological Processes**:
    - Respiratory processes
        - Controls carbon dioxide (CO_2) → carbonic acid
        - Dependent on respiratory minute volume, alveolar gas exchange
    - Metabolic processes

- Controlled by renal system
  - Distal tubule
  - Elimination of hydrogen (H+) ion
  - Conservation of bicarbonate
- H+ ion produced during metabolic processes
  - Anaerobic metabolism
  - Homeostasis of shifting electrolytes
  - Ketone production

o Compensatory processes
- Respiratory responses: Increasing or decreasing carbonic acid from lungs and increasing or decreasing ventilation (occurs in minutes to twenty-four hours).
- Renal responses: retention or excretion of bicarbonate in distal tubule. Retention of bicarbonate begins within six to twelve hours with most effect in three to four days.

o Buffer system
- Carbonic acid/ bicarbonate
  - Extracellular

o Protein buffer system
- Intracellular and plasma proteins (amphoteric)

o Potassium-Hydrogen exchange
- Intracellular, plasma, and renal

o Phosphate, Chloride-Bicarbonate exchange
- Renal tubules

o Acid excretion
- Carbonic acid excretion: Respiratory carbon dioxide (CO_2) excretion (increased rate)
- Metabolic acid excretion: Renal excretion of H+ ions or bicarbonate loss

- **Consequences**:
  Acid-base imbalances may alter the function of most cells, tissues, organs, with overall systemic consequences.
  - Electrolyte Imbalances
    - Hyperkalemia
      - Shift of potassium out of cell, H+ ions into cell in acidosis.
    - Hypercalcemia
      - Calcium released from albumin increasing amount of ionized calcium.

- CO_2 narcosis
- Cognitive function decline
- Musculoskeletal dysfunction
- Intracranial regulation alteration
- Altered drug metabolism, distribution, and elimination
- Cellular and organ function impairment: such as cerebral function. Acidosis puts the brain to sleep, alkalosis wakes it up.

Assessment/Attributes:

Manifestations due to underlying conditions, disease processes, and/or underlying fluid and electrolyte imbalances.

Subjective:

- Baseline history: Focus on underlying medical conditions including a focused assessment of the respiratory, renal, or other conditions; including but not limited to metabolic disorders, altered elimination, altered perfusion, poor nutrition, and medication therapies.
- Alterations in body functions: Focus on target organs and alterations.
- Concerning symptoms reported, aggravating or relieving factors.
- Medication use: Diuretics (altered elimination), medications containing bicarbonate, salicylates, narcotics and sedatives (respiratory depression)

Objective:

- Examination findings-disruptions usually overshadowed by underlying cause of imbalance:
  - Respiratory assessment
    - Respiratory rate and depth (fast, deep, slow, shallow)
    - Breathe odor (fruity in diabetic ketoacidosis [DKA])
    - Lung sounds (rales, rhonchi, none) noting location
  - Renal assessment
    - Urine output (too much, too little)
    - Presence of ketones in blood or urine
    - Accurate intake and output (I & O) measurements

Diagnostic Tests:

- Laboratory testing
  - Arterial blood gas-pH, partial pressure of carbon dioxide ($PaCO_2$), partial pressure of oxygen (PaO_2), and bicarbonate (HCO^-_3) concentrations; Base excess would reflect activation of compensatory mechanisms.

- Venous blood gas-same as arterial blood gas (ABG), but reflects oxygen utilization
- Basic metabolic panel-CO_2, electrolytes (potassium and calcium), and anion gap.
- Lactate (anaerobic metabolism)
- Complete Blood Count (CBC), White Blood Cells (WBCs) (infection), Hemoglobin and Hematocrit (Hgb & Hct) – evaluating oxygen carrying capacity

Clinical Management - Interdisciplinary:

Primary: Prevention by health Promotion or minimization of risk factors.

- Patient education and community-based interventions
  - Tobacco prevention and cessation
  - Diabetes management
  - Reduction in infection risk
  - Immunization management
- Target healthy lifestyle-regular physical activity, balanced diet, and avoid tobacco use

Secondary: Screening

- Diabetes screening

Tertiary: Treating the underlying cause.

- Collaborative interventions
  - Respiratory support: improved ventilation and gas exchange (O2 and CO2 regulation), ventilatory support
  - Fluid and electrolyte support: correction of fluid, potassium and other electrolyte imbalances

Interrelated Concepts:

- Nutrition: Starvation or malnutrition results in breakdown and utilization of fats for energy resulting in increasing ketone formation causing ketoacidosis.
- Elimination: Diarrhea causes an increased loss of base and electrolytes resulting in imbalance of acid-base.
- Fluids and Electrolytes: Changes in acid-base results in alterations in potassium and calcium. Fluid imbalance complicates cellular functions
- Perfusion: Decreased perfusion results in a shift from aerobic to anaerobic metabolism, which increases lactic acid formation resulting in lactic acidosis.
- Gas Exchange: Alterations in respiratory function shifts acid-base balance through the retention in the blood, or excretion of CO2 through ventilation.

- Metabolism: Abnormal glucose regulation results in metabolism of ketones and can lead to metabolic acidosis.
- Anxiety: Respiratory alkalosis from hyperventilation.

Exemplars:

New Mexico Nursing Education Consortium (NMNEC) Required Exemplars:

- Respiratory acidosis
- Metabolic acidosis
- Acidosis compensation

Optional Exemplars:

- Respiratory alkalosis
- Metabolic alkalosis

Resources:

Braun, C.A., & Anderson, C.M. (2011) Altered fluid, electrolyte, and acid-base balance. *Pathophysiology: A clinical approach* (2nd ed.). Philadelphia: Wolters Kluwer/Lippincott.

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Felver, L. (2013). Acid-base balance. In J. F. Giddens (Ed.*), Concepts for nursing practice* (2nd ed.) (pp. 75-84). St. Louis, MO: Mosby/Elsevier.

Holtzclaw, B. (2003). Alterations in thermoregulation. In Carrieri-Kohlman, V., Lindsey, A., & West, C., (Eds.), *Pathophysiological phenomena in nursing* (3rd ed.). St. Louis, MO: Saunders/Elsevier.

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