Electrolytes and Acid Base balance

FUNCTIONS OF BODY FLUID:

- Provides a medium for transporting nutrients to cells and wastes from cells and for transporting substances such as hormones, enzymes blood plates, and red and white blood cells.
- Facilitates cellular metabolism and proper cellular chemical functioning
- Acts as a solvent for electrolytes and non electrolytes

Functions of body fluid con't

- Helps maintain body temperature
- Facilitates digestion and promotes elimination
- Acts as a tissue lubricant

BODY FLUIDS:

- Water as a percent of body weight
  - Infants = 77%
  - Adult male=60%
  - Adult female= 50%
  - Elderly person =45%

BODY FLUIDS COMPARTMENTS:

- Intracellular
- Extracellular
  - Interstitial
  - intravascular

VARIATIONS IN FLUID CONTENT

- Age
- Sex
- Amount of body fat

FLUID AND ELECTROLYTE MOVEMENT:

- Diffusion
- Facilitated diffusion
- Active transport
- Osmosis
- Hydrostatic pressure
- Oncotic pressure (reabsorption) “keeping the fluid in”

ORGANS OF REGULATION

- KIDNEYS
- LUNGS
- HEART
- BLOOD VESSELS
- PITUITARY
- ADRENAL CORTEX
- PARATHYROIDS

ACID BASE BALANCE:

- Buffers attempt to bring a body fluid as close as possible to the Ph of normal body fluid
  - Carbonic Acid-Sodium Bicarbonate system and other buffer systems affect:
    - The kidneys
    - Plasma protein
    - Globins portion of hemoglobin

IMPLEMENTING to prevent or correct imbalances include:

- Dietary modification
- Modification of fluid intake
- Medication administration
- IV therapy
- Blood and blood product replacement
- Total Parenteral Nutrition (TPN)

EVALUATING:

- Drinking and eating patterns supplying fluid and electrolyte needs
- Urine output = to fluid intake
- Color, odor & specific gravity indicate healthy functioning of the kidney
- Fluid balance wt. I & O
- Initial signs or symptoms improved
- Pt's ability to practice self-care behaviors

ELECTROLYTES

- Electrolytes are substances whose molecules dissociate or split into ions when placed in water. Some develop a positive charge, others a negative charge. Ions with a positive charge(+) are cations. Ions with a negative charge(-) are anions.

Positive or Negative Electrolytes

Integral part of metabolic and cellular processes

- Cations (+)
  - Sodium
  - Potassium
  - Calcium
  - Magnesium
- Anions (-)
  - Chloride
  - Bicarbonate
  - Phosphate
  - Sulfate

Major Cations

- EXTRACELLULAR
  - SODIUM (Na+)

- INTRACELLULAR
  - POTASSIUM (K+)

Electrolyte Imbalances

- Hyponatremia/ hypernatremia
- Hypokalemia/ Hyperkalemia
- Hypomagnesemia/ Hypermagnesemia
- Hypocalcemia/ Hypercalcemia
- Hypophosphatemia/ Hyperphosphatemia
- Hypochloremia/ Hyperchloremia

Sodium

- Major extracellular cation
- Attracts fluid and helps preserve fluid volume
- Combines with chloride and bicarbonate to help regulate acid-base balance
- Normal range of serum sodium 135 - 145 mEq/L

Sodium and Water

- If sodium intake suddenly increases, extracellular fluid concentration also rises
- Increased serum Na+ increases thirst and the release of ADH, which triggers kidneys to retain water
- Aldosterone also has a function in water and sodium conservation when serum Na+ levels are low

Sodium-Potassium Pump

- Sodium (abundant outside cells) tries to get into cells
- Potassium (abundant inside cells) tries to get out of cells
- Sodium-potassium pump maintains normal concentrations
- Pump uses ATP, magnesium and an enzyme to maintain sodium-potassium concentrations
- Pump prevents cell swelling and creates an electrical charge allowing neuromuscular impulse transmission

Hyponatremia

- Serum Na+ level < 135 mEq/L
- Deficiency in Na+ related to amount of body fluid

Several types

a. Dilutional - results from Na+ loss, water gain
b. Depletional - insufficient Na+ intake
c. Hypovolemic - Na+ loss is greater than water loss; can be renal (diuretic use) or non-renal (vomiting)
d. Hypervolemic - water gain is greater than Na+ gain; edema occurs
e. Isovolumic - normal Na+ level, too much fluid

What Do You See?

- Primarily neurologic symptoms
  - Headache, N/V, muscle twitching, altered mental status, stupor, seizures, coma
- Hypovolemia - poor skin turgor, tachycardia, decreased BP, orthostatic hypotension
- Hypervolemia - edema, hypertension, weight gain, bounding tachycardia

What Do We Do?

- MILD CASE
  - Restrict fluid intake for hyper/isovolemic hyponatremia
  - IV fluids and/or increased po Na+ intake for hypovolemic hyponatremia
- SEVERE CASE
  - Infuse hypertonic NaCl solution (3% or 5% NaCl)
  - Furosemide to remove excess fluid
  - Monitor client in ICU

Hypernatremia

- Excess Na+ relative to body water
- Occurs less often than hyponatremia
- Thirst is the body's main defense
- When hypernatremia occurs, fluid shifts outside the cells
- May be caused by water deficit or over-ingestion of Na+
- Also may result from diabetes insipidus

What Do You See?

- Think S-A-L-T
  - Skin flushed
  - Agitation
  - Low grade fever
  - Thirst
- Neurological symptoms
- Signs of hypovolemia

What Do We Do?

- Correct underlying disorder
- Gradual fluid replacement
- Monitor for s/s of cerebral edema
- Monitor serum Na+ level
- Seizure precautions

Potassium

- Major intracellular cation
- Untreated changes in K+ levels can lead to serious neuromuscular and cardiac problems
- Normal K+ levels = 3.5 - 5 mEq/L

Balancing Potassium

- Most K+ ingested is excreted by the kidneys

Three other influential factors in K+ balance :

1. **Na+/K+ pump** Uses ATP to pump potassium into cells--Pumps sodium out of cells--Creates a balance
2. **Renal regulation** Increased K+ levels ⇒ increased K+ loss in urine--Aldosterone secretion causes Na+ reabsorption and K+ excretion
3. **pH level** Potassium ions and hydrogen ions exchange freely across cell membranes---Acidosis ⇒ hyperkalemia (K+ moves out of cells)----Alkalosis ⇒ hypokalemia (K+ moves into cells)

Hypokalemia

- Serum K+ < 3.5 mEq/L
- Can be caused by GI losses, diarrhea, insufficient intake, non-K+ sparing diuretics (thiazide, furosemide)
- Symptoms

Think S-U-C-T-I-O-N

- Skeletal muscle weakness
- U wave (EKG changes)
- Constipation,
- Toxicity of digitalis glycosides
- Irregular, weak pulse
- Orthostatic hypotension
- Numbness (paresthesias)

What Do We Do?

- Increase dietary K+
- Oral KCl supplements
- IV K+ replacement
- Change to K+-sparing diuretic
- Monitor EKG changes

Hyperkalemia

- Serum K+ > 5 mEq/L
- Less common than hypokalemia
- Caused by altered kidney function, increased intake (salt substitutes), blood transfusions, meds (K+-sparing diuretics), cell death (trauma)

What Do You See?

- Irritability
- Paresthesia
- Muscle weakness (especially legs)
- EKG changes (tented T wave)
- Irregular pulse
- Hypotension
- Nausea, abdominal cramps, diarrhea

What Do We Do?

- Mild
  - Loop diuretics (Lasix)
  - Dietary restriction
- Moderate
  - Kayexalate
- Emergency
  - 10% calcium gluconate for cardiac effects
  - Sodium bicarbonate for acidosis

Magnesium

- Helps produce ATP
- Role in protein synthesis & carbohydrate metabolism
- Helps cardiovascular system function (vasodilation)
- Regulates muscle contractions

Hypomagnesemia

- Serum Mg++ level < 1.5 mEq/L
- Caused by poor dietary intake, poor GI absorption, excessive GI/urinary losses
- High risk clients
  - Chronic alcoholism
  - Malabsorption
  - GI/urinary system disorders
  - Sepsis
  - Burns
  - Wounds needing debridement

What Do You See?

- CNS
  - Altered LOC
  - Confusion
  - Hallucinations
- Neuromuscular
  - Muscle weakness
  - Leg/foot cramps
  - Hyper DTRs
  - Tetany
  - Chvostek's & Trousseau's signs
- Cardiovascular
  - Tachycardia
  - Hypertension
  - EKG changes
- Gastrointestinal
  - Dysphagia
  - Anorexia
  - Nausea/vomiting

What Do We Do?

- Mild
  - Dietary replacement
- Severe
  - IV or IM magnesium sulfate
- Monitor
  - Neuro status
  - Cardiac status
  - Safety

Hypermagnesemia

- Serum Mg++ level > 2.5 mEq/L
- Not common
- Renal dysfunction is most common cause
  - Renal failure
  - Addison's disease
  - Adrenocortical insufficiency
  - Untreated DKA

What Do You See?

- Decreased neuromuscular activity
- Hypoactive DTRs
- Generalized weakness
- Occasionally nausea/vomiting

What Do We Do?

- Increased fluids if renal function normal
- Loop diuretic if no response to fluids
- Calcium gluconate for toxicity
- Mechanical ventilation for respiratory depression
- Hemodialysis (Mg++-free dialysate)

Calcium

- 99% in bones, 1% in serum and soft tissue (measured by serum Ca++)
- Works with phosphorus to form bones and teeth
- Role in cell membrane permeability
- Affects cardiac muscle contraction
- Participates in blood clotting

Calcium Regulation

- Affected by body stores of Ca++ and by dietary intake & Vitamin D intake
- Parathyroid hormone draws Ca++ from bones increasing low serum levels *(Parathyroid pulls)*
- With high Ca++ levels, calcitonin is released by the thyroid to inhibit calcium loss from bone *(Calcitonin keeps)*

Hypocalcemia

- Serum calcium < 8.9 mg/dl
- Ionized calcium level < 4.5 mg/Dl
- Caused by inadequate intake, malabsorption, pancreatitis, thyroid or parathyroid surgery, loop diuretics, low magnesium levels

What Do You See?

- Neuromuscular
  - Anxiety, confusion, irritability, muscle twitching, paresthesias (mouth, fingers, toes), tetany
- Fractures
- Diarrhea
- Diminished response to digoxin
- EKG changes

What Do We Do?

- Calcium gluconate for postop thyroid or parathyroid client
- Cardiac monitoring
- Oral or IV calcium replacement

Hypercalcemia

- Serum calcium > 10.1 mg/dl
- Ionized calcium > 5.1 mg/dl
- Two major causes
  - Cancer
  - Hyperparathyroidism

What Do You See?

- Fatigue, confusion, lethargy, coma
- Muscle weakness, hyporeflexia
- Bradycardia $\Rightarrow$ cardiac arrest
- Anorexia, nausea/vomiting, decreased bowel sounds, constipation
- Polyuria, renal calculi, renal failure

What Do We Do?

- If asymptomatic, treat underlying cause
- Hydrate the patient to encourage diuresis
- Loop diuretics
- Corticosteroids

Phosphorus

- The primary anion in the intracellular fluid
- Crucial to cell membrane integrity, muscle function, neurologic function and metabolism of carbs, fats and protein
- Functions in ATP formation, phagocytosis, platelet function and formation of bones and teeth

Hypophosphatemia

- Serum phosphorus < 2.5 mg/dl
- Can lead to organ system failure
- Caused by respiratory alkalosis (hyperventilation), insulin release, malabsorption, diuretics, DKA, elevated parathyroid hormone levels, extensive burns

What Do You See?

- Musculoskeletal
  - muscle weakness
  - respiratory muscle failure
  - osteomalacia
  - pathological fractures
- CNS
  - confusion, anxiety, seizures, coma
- Cardiac
  - hypotension
  - decreased cardiac output
- Hematologic
  - hemolytic anemia
  - easy bruising
  - infection risk

What Do We Do?

- MILD/MODERATE
  - Dietary interventions
  - Oral supplements
- SEVERE
  - IV replacement using potassium phosphate or sodium phosphate

Chloride

- Major extracellular anion
- Sodium and chloride maintain water balance
- Secreted in the stomach as hydrochloric acid
- Aids carbon dioxide transport in blood

Hypochloremia

- Serum chloride < 96 mEq/L
- Caused by decreased intake or decreased absorption, metabolic alkalosis, and loop, osmotic or thiazide diuretics

What Do You See?

- Agitation, irritability
- Hyperactive DTRs, tetany
- Muscle cramps, hypertonicity
- Shallow, slow respirations
- Seizures, coma
- Arrhythmias

What Do We Do?

- Treat underlying cause
- Oral or IV replacement in a sodium chloride or potassium chloride solution

Hyperchloremia

- Serum chloride > 106 mEq/L
- Rarely occurs alone
- Caused by dehydration, renal failure, respiratory alkalosis, salicylate toxicity, hyperpara-thyroidism, hyperaldosteronism, hypernatremia

What Do You See?

- Metabolic Acidosis
  - Decreased LOC
  - Kussmaul's respirations (deep, rapid, and labored **breathing**.
  - Weakness
- Hypernatremia
  - Agitation
  - Tachycardia, dyspnea (shortness of breath), Edema

What Do We Do?

- Correct underlying cause
- Restore fluid, electrolyte and acid-base balance
- IV Lactated Ringer's solution to correct acidosis

Acid-Base Balance

Acid-Base Basics

- Balance depends on regulation of free hydrogen ions
- Concentration of hydrogen ions is measured in pH
- Arterial blood gases are the major diagnostic tool for evaluating acid-base balance

Arterial Blood Gases

pH	7.35 - 7.45
$PaCO_2$	35 - 45 mmHg
HCO_3	22-26 mEq/L

Acidosis

- pH < 7.35
- Caused by accumulation of acids or by a loss of bases

Alkalosis

- pH > 7.45
- Occurs when bases accumulate or acids are lost

Regulatory Systems

- Three systems come into play when pH rises or falls
  - Chemical buffers
  - Respiratory system
  - Kidneys

Chemical Buffers

- Immediate acting
- Combine with offending acid or base to neutralize harmful effects until another system takes over
- Bicarb buffer - mainly responsible for buffering blood and interstitial fluid
- Phosphate buffer - effective in renal tubules
- Protein buffers - most plentiful - hemoglobin

Respiratory System

- Lungs regulate blood levels of CO_2
- $CO_2 + H_2O$ = Carbonic acid
- High CO_2 = slower breathing (hold on to carbonic acid and lower pH)
- Low CO_2 = faster breathing (blow off carbonic acid and raise pH)
- Twice as effective as chemical buffers, but effects are temporary

Kidneys

- Reabsorb or excrete excess acids or bases into urine
- Produce bicarbonate
- Adjustments by the kidneys take hours to days to accomplish
- Bicarbonate levels and pH levels increase or decrease together

Arterial Blood Gases (ABG)

- Uses blood from an arterial puncture
- Three test results relate to acid-base balance
  - pH
  - $PaCO_2$
  - HCO_3

Acid-Base Imbalances

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

Respiratory Acidosis

- Any compromise in breathing can result in respiratory acidosis
- Hypoventilation ⇒carbon dioxide buildup and drop in pH
- Can result from neuromuscular trouble, depression of the brain's respiratory center, lung disease or airway obstruction

ABG Results

- Uncompensated
  - pH < 7.35
  - $PaCO_2$ >45
  - HCO_3 Normal
- Compensated
  - pH Normal
  - $PaCO_2$ >45
  - HCO_3 > 26

Clients At Risk

- Post op abdominal surgery
- Mechanical ventilation
- Analgesics or sedation

What Do You See?

- Apprehension, restlessness
- Confusion, tremors
- Decreased DTRs
- Diaphoresis
- Dyspnea, tachycardia
- N/V, warm flushed skin

What Do We Do?

- Correct underlying cause
- Bronchodilators
- Supplemental oxygen
- Treat hyperkalemia
- Antibiotics for infection
- Chest PT to remove secretions
- Remove foreign body obstruction

Respiratory Alkalosis

- Most commonly results from hyperventilation caused by pain, salicylate poisoning, use of nicotine or aminophylline, hypermetabolic states or acute hypoxia (overstimulates the respiratory center)

ABG Results

- Uncompensated
  - pH > 7.45
  - $PaCO_2$ < 35
  - HCO_3 Normal
- Compensated
  - pH Normal
  - $PaCO_2$ < 35
  - HCO_3 < 22

What Do You See?

- Anxiety, restlessness
- Diaphoresis
- Dyspnea (⇑ rate and depth)
- EKG changes electrocardiogram
- Hyperreflexia, paresthesias
- Tachycardia
- Tetany

What Do We Do?

- Correct underlying disorder
- Oxygen therapy for hypoxemia
- Sedatives or antianxiety agents
- Paper bag breathing for hyperventilation

Metabolic Acidosis

- Characterized by gain of acid or loss of bicarb
- Associated with ketone bodies
  - Diabetes mellitus, alcoholism, starvation, hyperthyroidism
- Other causes
  - Lactic acidosis secondary to shock, heart failure, pulmonary disease, hepatic disease, seizures, strenuous exercise

ABG Results

- Uncompensated
  - pH < 7.35
  - PaCO2 Normal
  - HCO3 < 22
- Compensated
  - pH Normal
  - PaCO2 < 35
  - HCO3 < 22

What Do You See?

- Confusion, dull headache
- Decreased DTRs
- S/S hyperkalemia (abdominal cramps, diarrhea, muscle weakness, EKG(electrocardiogram) changes)
- Hypotension,
- Lethargy, warm & dry skin

What Do We Do?

- Regular insulin to reverse DKA (**Diabetic ketoacidosis)**
- IV bicarb to correct acidosis
- Fluid replacement
- Dialysis for drug toxicity
- Antidiarrheals

Metabolic Alkalosis

- Commonly associated with hypokalemia from diuretic use, hypochloremia and hypocalcemia
- Also caused by excessive vomiting, NG suction, Cushing's disease, kidney disease or drugs containing baking soda

ABG Results

- Uncompensated
  - pH > 7.45
  - $PaCO_2$ Normal
  - HCO_3 >26
- Compensated
  - pH Normal
  - $PaCO_2$ > 45
  - HCO_3 > 26

What Do You See?

- Anorexia
- Apathy
- Confusion
- Hypotension
- Loss of reflexes
- Muscle twitching
- Nausea
- Paresthesia
- Polyuria
- Vomiting
- Weakness

What Do We Do?

- IV ammonium chloride
- D/C thiazide diuretics and NG suctioning

  Nasogastric suction involves removing solids, liquids, or gasses from the stomach or small intestine by inserting a tube
- Antiemetics