Unit VII Fluids and Electrolytes

YouTube
- Fluid & Electrolytes Part 1 through 3 10” each Campbelliteaching
- Osmosis and Diffusion Part 1-4 10”
- Rec’d Acid-Base Balance Part 1,2, 3 davidlaw888 (ATI)

Fluid & Electrolytes
- Function of fluid
  - Transport of nutrients to & wastes from cells
  - Helps maintain normal body temp.
  - Lubricates & cushions
  - Facilitates digestion & elimination
  - Maintains vascular volume
  - Solvent for electrolytes

Fluid & Electrolytes
- Function of electrolytes
  - Body water regulation & osmolality
  - Acid-base balance
  - Enzyme activity
  - Neuromuscular activity

Fluid & Electrolytes
- Body fluid distribution
  - Water & electrolytes
  - 60% of weight (adult & children>2yrs.)
    - ICF – intracellular fluid = 40%
    - ECF – extracellular fluids = 20%
      - Intravascular 5%
      - Interstitial 15%

Electrolytes
- Plasma Cations += 154
  - Sodium (Na) 142
  - Potassium (K) 5
  - Calcium (Ca²⁺) 5
  - Magnesium (Mg²⁺) 2
- Plasma Anions -= 154
  - Chloride (Cl⁻) 104
  - Bicarbonate (HCO₃⁻) 26
  - Phosphate (HPO₄²⁻) 2
  - Sulfate (SO₄²⁻) 1
  - Organic acids & proteinate 22
- ICF Cations += 200
  - Potassium 150
  - Magnesium 40
  - Sodium 10
- ICF Anions -= 200
  - Phosphates
  - Sulfates (150)
  - Bicarbonate 10
  - Proteinate 40
**Acid-Base Balance**

- pH – H⁺ ion concentration in blood
- Hydrogen is a product of metabolism
- Normal pH 7.35 – 7.45
- Chemical buffer systems
  - Remove or release Hydrogen ions
  - ECF buffers – phosphates & plasma proteins
  - ICF buffers – phosphates, proteins, & Hemoglobin
  - Bicarbonate – Carbonic acid buffer system
  - Acid – donates H⁺ ions
  - Base – accepts H⁺ ions

**Body Fluid Balance**

- **Routes of Gains & Losses**
  - **Gains**
    - Food 800-1000ml
    - Fluid intake 1100-1400ml
    - Oxidative metabolism 300ml
  - **Losses**
    - Lungs 400ml
    - Skin 500-600ml
    - G.I tract 100-200
      - Small intestine absorbs fluid
    - Kidneys – 1200-1500

**Fluid Regulation**

- Osmolality (Tonicity) = concentration
- Iso-osmolar, hypo-osmolar, hyperosmolar
- Normal serum osmolality = 280-295mOsm/kg of H₂O

**Fluid Regulation - Osmosis**

- Osmosis
  - Osmotic pull by particles /unit of water (Osmolality)
  - Movement of fluid from area of < concentration to area of > concentration

- Hypotonic
- Hypo-osmolar
- Semi permeable membrane
- Hypertonic
- Hyperosmolar
- Semi permeable membrane
**Fluid Regulation – Kidneys**

- Regulation of ECF volume & osmolality by selective retention & excretion
- Hydrostatic pressure
- Filtration = excretion of urine/waste products
- GFR = 125ml/minute
- Normal urine output – 20-30ml/hr

**Renin-Angiotensin-Aldosterone System**

- Renin secretion
- Angiotensin converted to Angiotensin I
- Angiotensin I converted to Angiotensin II

**Aldosterone**

- Angiotensin II – adrenals* secrete aldosterone

Kidneys retain Na & H₂O

**Antidiuretic Hormone (ADH)**

- Hypothalamus Osmoreceptors

- ADH
- Kidney
- Urine volume
- Urine concentration

- Plasma Osmolality

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**Thirst mechanism**

- Thirst Center
- Plasma Omolality
- Plasma Volume
- Dec. Potassium or Inc. Sodium
- Dry oropharyngeal Mucous membranes
- Psychological factors

**Renin-Angiotensin-Aldosterone System**

- BP or Na
- Glomerulus
- Renin secretion
- Liver
- Angiotensin converted to Angiotensin I
- Lungs
- Angiotensin I converted to Angiotensin II
- Adrenals produce aldosterone

**Aldosterone**

- Angiotensin II – adrenals* secrete aldosterone

Kidneys retain Na & H₂O

**Antidiuretic Hormone (ADH)**

- Hypothalamus Osmoreceptors

- ADH
- Kidney
- Urine volume
- Urine concentration

- Plasma Osmolality
Electrolyte Balancing Act

- Active transport
  - ATP – solutes move from area of < concentration to areas of > concentration
- The body expands energy to maintain the extracellular Na and the intracellular K by means of cell membrane Sodium – Potassium pump.

Sodium Balance

- Normal serum sodium (Na+)
  - 135 – 145 mEq/L (Cl –95 - 108)
- 95% in ECF
- Primary role
  - Control H2O distribution & volume
- Normal intake 50-90mEq as NaCl
- Kidney conserves or excretes Na prn

Potassium (K+)

- Function
  - Regulation of ICF osmolality
  - Promotes transmission/conduction of nerve impulses
  - Promotes contraction of skeletal, cardiac, & smooth muscle
  - Maintenance of acid-base balance

Potassium (K+)

- Major intracellular cation–150mEq/L
- Normal se levels – 3.5–5mEq/L
- Poor storage – daily requirement needs
- Kidneys excrete 80-90% of K+

Dietary Sources of K

- Meats
- Vegetables
- Fruits
- Dried fruits, nuts, seeds
- Chocolate

Calcium

- Se Ca++
  - Total 8.5 –10.5 mg/dL (100ml)
  - Bound with protein & ionized
  - Ionized – 4 – 5 mEq/L
  - 99% in bones & teeth
Calcium - Function
- Transmission & conduction of nerve impulses
- Stimulates skeletal, smooth, & cardiac muscle contraction
- Promotes coagulation
- Bone & teeth formation
- Hormone secretion

Calcium – Regulation
- Vitamin D
- Phosphates
  - $\text{PO}_3^-$
- Inverse relationship with Calcium
- PTH
- Calcitonin

Magnesium
- Distribution
  - 2/3 found in bones
  - 1/3 found in ICF
  - 1% in ECF
- Absorbed in small bowel
- Excreted by kidneys
- Function
  - Intracellular metabolism
  - Neuromuscular - similar to calcium

Bicarbonate
- $\text{HCO}_3^-$
- Major chemical buffer in ECF & ICF
- Regulated by kidneys
- Arterial measurement
  - 20-26 mEq/L
- Venous measurement
  - $\text{CO}_2$ content 24-30 mEq/L

ABG Values
- pH 7.35 – 7.45
  - <7.35
  - >7.45
- PaCO$_2$ 35-45 mmHg
  - <35 (hypocapnia)
  - >45 (hypercapnia)
- HCO$_3$ 20-26 mEq/L
  - <20 (acidosis)
  - >26 (alkalosis)

Acid-Base
Acid-Base - Acidosis

Gain of acid: 
\[ H_2CO_3 \rightarrow H_2O + CO_2 \]

\[ H_2CO_3 \rightarrow H + HCO_3^- \]

Death

Gain of acid: 
\[ H_2CO_3 \rightarrow H_2O + CO_2 \]

Loss of base: 
\[ HCO_3^- \rightarrow H_2CO_3 \]

Loss of base: 
\[ HCO_3^- \rightarrow H_2CO_3 \]

Death

Metabolic Acidosis – Mechanism
- Accumulation of fixed acids
  - Lactic acidosis
  - Renal failure
  - Ketoacidosis
  - Ingestion
    - ASA
    - Antifreeze
- Loss of base
  - Renal tubular acidosis
  - Carbonic anhydrase inhibitors
    - Diamox
    - Diarrhea

Metabolic Acidosis - Symptoms
- pH \( \downarrow \)
- HCO_3^- \( \downarrow \)
- Hyperventilation (PaCO_2 \( \downarrow \)) compensatory
- Lethargy/weakness
- Hyperkalemia
- Hypotension & myocardial depression

Respiratory Acidosis – Causes
- Inadequate excretion of CO_2
- Acute or chronic respiratory alterations
- Risk factors favoring hypoventilation
  - Obesity
  - Tight binders/dressings
  - Postoperative pain
  - Abdominal distention

Respiratory Acidosis – Symptoms
- ABG’s
  - pH \( \downarrow \)
  - PaCO_2 \( \uparrow \)
  - HCO_3^- \( \uparrow \) (\( \uparrow \) compensatory)
- Headache
- Hypertension
- Hyperkalemia
- Hypoxemia
Acid-Base

Acidosis 7.35
Alkalosis 7.45
Death 7.80

Loss of acid

H₂CO₃

1 part acid

HCO₃⁻ 1.2mEq/L

20 parts base

24mEq/L

H₂O + CO₂ → H₂CO₃ → H + HCO₃⁻

Metabolic Alkalosis - Causes

- Fixed acid loss
- Vomiting/G.I suction
- Hypokalemia
- Excess bicarbonate intake
- Alkali ingestion
- I.V. NaHCO₃
- Excess bicarbonate reabsorption

Metabolic Alkalosis - Symptoms

- ABG’s
  - pH ↑
  - HCO₃⁻ ↑
  - PaCO₂ ↑ (↑ compensatory)
- Hypoventilation
- Decreased LOC
- Hypokalemia
- Hypochloremia
- Tetany/paresthesia

Respiratory Alkalosis

- Causes relate to hyperventilation
  - Anxiety
  - High fever
  - Thyrotoxicosis
  - Hypoxemia
  - Salicylate intoxication (early)
Respiratory Alkalosis - Symptoms

- ABG's
  - pH ↑
  - PaCO2 ↓
  - HCO3 \( \rightarrow \) (\( \downarrow \) compensated)
- Lightheadedness/confusion
- Inability to concentrate
- Paresthesia
- Palpitations
- Dry mouth

Influencing Factors in Total Body Water

- **Body fat**
  - Fat cells contain less water
- **Sex**
  - Women less body fluid than men
- **Age**
  - Infants
    - 70-80% body weight (Adult 60%)
  - 50% extracellular (Adult 20%)
  - Older adult
    - \( \downarrow \) % of body weight

Influencing Factors

- **Elderly**
  - Diminished thirst response
  - Altered ADH response
  - Decreased ability to concentrate urine
  - Chronicity
  - Deblitation
  - Changes in cognition
  - Infant - child, more risk for dehydration, esp. if vomiting and diarrhea

Risk Factors

- Compromised regulatory mechanisms
- Congestive heart failure
- Renal failure
- Cirrhosis
- Steroid excess
- ADH stimulation
- Excess sodium containing fluids/foods
- IV solutions

Alterations in fluid intake & output

- Medications
- G.I.
  - Dysphagia
  - Nausea/vomiting
  - Diarrhea
  - Insufficient intake
  - G.I. suction
- Restraints

- Skin
  - Diaphoresis
  - Wounds/burns
- Fever
  - Increase in metabolism
  - Tachypnea
  - Blood loss

History and Interview

- Age
- Acute illness
- Respiratory/Cardiovascular disorders
- Chronic illness
- Renal / G.I. disorders
- Environment
- Diet/ lifestyle
- Medications
**Normal Findings**

- General
- VS
- Weight
- Intake & Output
- Urine
- Skin turgor
- Mucous membranes
- Thirst
- Edema
- Neck Veins
- Neuromuscular signs

**Diagnostic Tests**

- Serum electrolytes
  - Sodium
  - Potassium
  - Chloride
  - CO$_2$
  - Serum osmolality
  - ABG’s
  - Hematocrit
- BUN
- Creatinine
- BUN:creatinine ratio
- Specific gravity
- Urine osmolality

**Isotonic Imbalance - Fluid Volume Deficit (FVD)**

- Decrease in intravascular & interstitial fluids = hypovolemia
- Isotonic FVD
  - Equal water & lyte loss
  - Hemorrhage
  - Diaphoresis
  - Diuretics

**Fluid Volume Deficit - Isotonic**

- S&S
  - BP
  - Heart rate
  - Mucous membranes
  - Skin turgor
  - Weight
  - Venous filling
  - Urine output
  - LOC

**Assessment - FVD - Symptoms**

- Thirst
- Muscle weakness
- Decreased skin turgor
- Dry mucous membranes
- Soft & sunken eyeballs
- Decreased temperature if no sepsis
- Tachycardia
- Narrowed pulse pressure
- Postural hypotension
- Decreased urinary output, weight loss
- Neurological changes – apprehension, headache, confusion

**FVD - Diagnostic Tests**

- Serum Na$^+$ => or ↑ 145
- BUN ↑ >25
- Hematocrit ↑ >50%
- Specific gravity ↑ > 1.025

Increased solute to solvent
Hemo-concentration
Extracellular Fluid Volume Excess (FVE)

- Abnormal fluid retention in intravascular & interstitial spaces
- Secondary to ↑ serum Na
- Sodium & Water retained in proportion

Isotonic Fluid Volume Excess

- Causes
  - Congestive heart failure
  - Renal failure
  - Excessive sodium intake
  - Increased serum aldosterone levels
  - Steroids

Isotonic Fluid Volume Excess

- S&S
  - Weight
  - Edema
  - BP
  - Urine output
  - Venous filling
  - Breath sounds

FVE – Manifestations

- Cardiovascular
  - B.P.
  - Pulse quality
  - Pitting edema
    - Sacral
    - Peripheral
  - Weight gain
  - Distended veins
  - S₂ heart sound

- Respiratory
  - Constant, irritating cough
  - Crackles (Rales)
  - Dyspnea
  - Cyanosis
  - Pleural effusion

- Neurological
  - LOC

FVE – Diagnostic Tests

- Serum sodium
- Hematocrit (% RBC’s in plasma)
- Urine specific gravity
- BUN

Osmolar Imbalances

- Dehydration
  - Hyperosmolar FVD
    - Water loss > lyte loss
  - Hypo-osmolar FVE
    - Water gain > lyte gain

- Water Excess
  - Hyperosmolar FVD
    - Water loss > lyte loss
  - Hypo-osmolar FVE
    - Water gain > lyte gain

NORMAL VOLUME

EXCESS VOLUME

Na 140mEq/L

ISOTONIC

FLUID

Na 140

Na 150

Na 140

Na <135
Hypo-osmolar Imbalance – H₂O excess

- Causes
  - Excessive amounts of hypotonic (hypo-osmolar)solutions
  - D₅W
  - 0.45% saline
  - Excessive intake of free water

Intracellular Fluid Volume Excess (ICFVE)

- Fluid shift from extracellular spaces to intracellular
- Due to serum hypo-osmolality
- Cellular edema

Effect of Na Imbalance on Cell

**Hypernatremia:**

Na > 145mEq/L

Cell shrinks as water is pulled out into ECF

**Hyponatremia:**

Na < 135mEq/L

Due to excess water gain or Na loss

Cell swells as water is pulled in from ECF
**Hypernatremia – Symptoms**
- S&S of FVE or FVD
- Thirst?
- Temperature?
- Mucous membranes?
- Restlessness, weakness with mild to moderate ↑Na
- Disorientation, delusions, hallucinations with severe ↑Na
- Lethargy, stupor, coma
- Muscle irritability and convulsions

**Hyponatremia**

**Hyponatremia – Symptoms**
- Relate to Na level
  - 120-125mEq/L
    - Nausea
    - Malaise
  - 115-120 mEq/L
    - Headache
    - Lethargy
    - Obtundation
  - <110-115 mEq/L
    - Seizures
    - Coma
- Volume status
  - ECF depletion
  - Weakness
  - Fatigue
  - Muscle cramps
  - Postural dizziness
- Lab data
  - Se Na?
  - Ua Na?
  - Se osmolality?

**HYPOKALEMIA**
- Serum K⁺ < 3.5 mEq/L
- Causes
  - Inadequate nutrient intake
  - G.I. Losses
  - Renal losses
  - Stress – increased cortisol levels
  - Steroids
  - Alkalosis

**Hypokalemia – Symptoms**
- Musculoskeletal
  - Weakness
  - Paralysis
  - Leg cramps
- G.I.
  - Ileus
  - Anorexia
  - Vomiting
- Respiratory
  - Respirations?
  - SOB
  - Apnea
- Renal
  - Polyuria
- Cardiovascular

**Hyperkalemia Se K⁺ > 5.0 mEq/L**
- Causes
  - Decreased potassium excretion
    - Oliguric renal failure
    - Potassium sparing diuretics
  - High potassium intake
    - Excess oral potassium supplements
    - Excessive or rapid IV K⁺ replacement
    - Shift of K out of cells
      - Acidosis, tissue trauma, malignant cell lysis (chemotherapy)
Hyperkalemia – Symptoms
- Cardiovascular
  - EKG changes
  - Dysrhythmias
  - Weakened contractility
  - Tachycardia then bradycardia
  - Cardiac arrest
- GI
  - Nausea
  - Intestinal colic
  - Hyperactive bowel sounds

Hyperkalemia - Symptoms
- Neuromuscular
  - Vague muscle weakness
  - Flaccid muscle paralysis
  - Paresthesia
- Renal
  - Oliguria
  - Anuria

Hypercalcemia – Causes
- Metastatic Cancer
- Immobilization
- Hyperparathyroidism
- Intake
  - Thiazide diuretics, Lithium
  - Excess intake of Ca^2+ antacids
  - Excess intake of Vitamins A or D

Hypercalcemia – Symptoms
- Neuromuscular weakness
- Renal
  - Polyuria (DI)
  - Hypercalcuria
- GI
  - N & V
  - ↓ peristalsis
  - Constipation
  - Cardiovascular
  - Impaired cerebral functioning

Hypocalcemia – Symptoms
- Neuromuscular
  - Tetany
  - ↓ threshold potential – less stimulus required for action potential
  - Hyperexcitability of motor & sensory nerves
  - Paresthesia
  - Trousseau’s sign
  - Chvostek’s sign

Hypermagnesemia – Symptoms
- Diminished neuromuscular transmission
- Decreased muscle function
- Hypotension
- Respiratory depression
- Cardiac arrest
Hypomagnesemia <1.8 mg/dL

Causes
- Losses from G.I tract
- Alcoholism
- Rapid administration of citrated blood
- Medications
  - Loop diuretics
  - Cisplatin

Nursing Diagnosis
- Fluid volume excess
- Fluid volume deficit
- Ineffective breathing pattern
- Impaired mobility
- Impaired skin integrity
- Altered oral mucous membranes

Nursing Interventions
- Assess fluid volume status
- Obtain daily weights
  - 1 liter = 1 kg (2.2 lb.)
- Measure & calculate I & O
- Monitor lab values
- Provide frequent mouth care
- Administer tube feedings &/or IV fluids
- Protect skin integrity
- Safety – implement measures to prevent falls
- Pulmonary toilet
- Offer fluids as appropriate
- Medications

Fluid Types
- Oral rehydration.
- Intravenous solutions
  - Isotonic electrolyte solutions to treat hypotensive patient – expands plasma volume.
    - Lactated Ringer's.
    - 0.9% Normal Saline.
  - Hypotonic solutions – provides free water & electrolytes – allows kidneys to select & retain needed amounts. Decreases intravascular osmolality.
    - 0.45% N.S.
    - D5%/0.2%N.S.

Parenteral Fluids
- Purposes of Fluid Therapy
  - Maintenance Needs
    - Fluids
    - Electrolytes
  - Replacement
  - Correction of electrolyte disturbances

Assessment
- I & O
- Daily body weights
- Vital signs
- Skin turgor
- Urinary specific gravity
- Laboratory values
- I.V. site
Crystalloids

- Dextrose Solutions
  - D5W
    - Isotonic \( \rightarrow \) Hypotonic
    - D5W is 5% dextrose in water is hypotonic so it moves fluid into the cells out of the circulation
    - Free water to aid renal excretion of solutes
    - Calories 50 grams Dextrose
    - Avoid excess

- Sodium Chloride solutions
  - Isotonic Saline (0.9% NaCl)
  - Expands extracellular fluid
  - Does not enter the ICF
  - Use
    - ECF deficits
    - Hyponatremia
    - Hypochloremia
    - Metabolic alkalosis

- 0.45% NaCl
  - Hypotonic
  - Provides Na, Cl, free water
  - Basic fluid for maintenance
  - Uses
    - Maintenance
    - Hypovolemia with hypernatremia

- Balanced electrolyte solutions
  - Lactated Ringers (Na, Cl, K, Ca, lactate)
    - Lactate \( \rightarrow \) Bicarbonate
    - Metabolic acidosis
    - Third spacing
    - Fluid resuscitation
  - Normosol
  - Isolyte
  - Plasma-Lyte

Colloids

- Protein or starch molecules in fluid
- Increase osmotic pressure – volume expansion
- Albumin
  - 5% – equivalent to plasma
  - 25% - hyperoncotic
  - Plasma expander
- Dextran
  - Low molecular weight (dextran 40)
  - High molecular weight (dextran 70)
- Hetastarch
- Supplemental fat emulsions (Lipids)

Adverse effects of IV therapy

- Fluid Volume Excess/Deficit
- Activity intolerance
- Impaired skin integrity
- Impaired tissue perfusion
- Risk for dysrhythmias
- Risk for injury
- Electrolyte imbalances (specify)
- Altered nutrition
- Ineffective breathing patterns
Study Guide

- List assessment findings for fluid volume deficit.
- List assessment findings for fluid volume excess.
- Identify fluid and electrolyte issues for infants and elderly.
- Know the compensating mechanisms most likely to occur in the presence of respiratory acidosis, respiratory alkalosis, metabolic acidosis, metabolic alkalosis.
- Be aware of causes and symptoms of potassium imbalances, sodium imbalances.
- List ways to assess for fluid retention.
- Identify the signs that indicate that fluid replacement is needed.