Disorders of Fluid & Electrolyte Balance

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Class 6 Objectives

- Upon completion of this lesson, the student will be able to
- describe the outcomes associated with hypo and hypervolemia.
- distinguish between the different etiologies of major electrolyte imbalances.
- list the manifestations of electrolyte imbalances.
- identify normal distribution of ICF and ECF.
- state the normal serum values for Na, K, Cl, Mg, PO_4 ,Ca.

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Starling's Law of the Capillary

- Fluids leave (filtration) or enter (re-absorption) the capillaries depending on how the pressure in the capillary and interstitial spaces relate to one another
- Volume re-absorbed is similar to volume filtered: "A net equilibrium"
- Regulates relative volumes of blood & interstitial fluid

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Capillary Exchange

- The 5% of blood in the systemic capillaries = the bulk of blood that exchanges materials with systemic tissue cells
- Substances that pass through thin capillary walls into interstitial fluid and then into cells are: nutrients & oxygen
- Substances that are secreted by tissue cells and removed from them are: wastes & CO2

Fluids

- Distribution of total body water (TBW)
  - 60% of adult body weight is fluid
    - Gender, body mass & age considerations
  - Intracellular (ICF, within cells = 40% of body weight)
  - Extracellular (ECF, plasma, interstitial & lymph =20% of body weight)
- 1 Litre water = 2.2lb or 1 kg

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Developmental Differences

- **Infants & young children**
  - **Four areas of immature functioning**
    - **Increased fluid intake and output relative to size**
      - **Total body fluid is 20% more than adults**
    - **Greater surface area relative to size: > water loss through skin**
    - **Increased metabolic rate up to 2 years**
    - **Immature kidney function**
      - **requires more fluid to excrete wastes**

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Fluid Shifts "Third Spacing"

- Excess fluid in interstitial spaces and connective tissues between cells [edema]

OR

- **Excess fluid in potential spaces [effusion]**
  - peritoneal cavity
  - pericardial sac
  - synovial cavities of joints
  - alveoli or intra-pleural spaces

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Fluid Shifts "Third Spacing"

- Etiology
  - Caused by an increase in filtration and/or decrease in reabsorption due to altered capillary forces
- Pathophysiology
  - **Lymph edema**
  - **Angioedema**

Mechanisms causing third spacing & edema

- massive inflammation
- venous obstruction
- increased blood volume
- low serum albumin

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Hypovolemia

- A decrease in the ECF volume
  - Intravascular and interstitial volume
- Isotonic volume deficit may be due to
  - Decreased intake of isotonic fluids
  - Or excessive
    - vomiting or diarrhea
    - hemorrhage
    - urine output

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Hypovolemia

- Hematocrit (Hct) is sensitive to fluid shifts
  - **volume (%) of erythrocytes in whole blood**
  - **40-54 mL/dL males**
  - **37-47 mL/dL females**
  - **11.2-16.5 mL/dL children**
- **BUN will be elevated d/t < volume**
  - **11-23 mg/dL**

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Hypovolemia: manifestations

- Decreased tissue perfusion
  - Check capillary refill time
- Decreased blood volume
  - Hypotension, tachycardia, oliguria
- Tissue dehydration
  - Loss of skin turgor
  - Possible temperature elevation

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Hypovolemia

- Nursing Responsibilities:
  - calculate I & O frequently
    - minimal urinary output = 30cc/hr
    - check urine specific gravity
  - check O2 saturations
  - draw & analyze blood gases
  - auscultate lungs (side to side)
  - check temperature distal from heart
  - give isotonic solutions (oral or IV)
    - Normal saline; dextrose, Ringer's lactate
  - give a fluid bolus as ordered

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Hypervolemia

- Excess of isotonic fluid in the intravascular and interstitial spaces
  - Isotonic fluid retention
    - Olguric state r/t renal failure
  - Secondary Hyperaldosteronism
    - Inappropriate renal reabsorption of water and sodium,and increased renal secretion of potassium
  - Iatrogenic hypervolemia

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Hypervolemia

- Patho
  - An excess in blood volume results in elevated CHP and third spacing
  - Clinical manifestations
    - Edema
    - Hypertension
    - Bounding pulse
    - Increased urinary output

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Major Electrolytes

- Electrolytes
  - Na+, K+, Ca++, Mg+ = cations
  - HCO-3, Cl-, PO-4 = anions
- ICF = K+
- ECF = Na+
  - osmosis
  - osmolarity
  - capillary dynamics

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Hyponatremia
(Na+ < 135 mEq/L)

- **Low sodium determined by blood chemistry**
  - **The most common electrolyte imbalance:**
    - **2.5% of hospitalized patients**
  - **Sodium supports neuron transmission**
- Mechanism and examples
  - **Free water gain**
  - **Deficient sodium intake**
  - **Renal sodium loss in excess of water**
  - **Water in excess of sodium gain**

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Hyponatremia
(Na+ < 135 mEq/L)

- Manifestations
  - Water excess rapid weight gain
  - Na+ loss neurological symptoms
    - irritability, seizures, < LOC
  - Muscle cramps
  - Anorexia/ Nausea/Vomiting (subtle signs)
- Treat water excess
  - Fluid restriction (I&O)
- Treat sodium loss
    - Oral or IV sodium

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Hypernatremia
(Na+ >145 mEq/L)

Etiology
- Water loss or sodium gains
  - **Elderly / or comatose patients**
  - **Na+ intake > water intake**
  - **Diabetes insipidus (excessive fluid loss) < production of ADH**
  - **Damage to hypothalamic thirst center?**
    - **Tumor or CVA?**
- Manifestations
  - Thirst, dry tongue
  - Restlessness; < LOC; Coma; Intracranial bleeds
  - Weight changes

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Hypernatremia
(Na+ >145 mEq/L)

Treatment (Rx)

- Dilute Na+ and promote secretion
- Fluids (5% D/W) and diuretics
- Always check LOC
  - loose alertness & orientation
    - sepsis, head injury, intracranial bleed
- Sodium pulls fluid to cause blood vessels to burst

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Potassium (K+)
3.5-5.0 mEq/L

- Primarily an intracellular ion; small amount in plasma is essential for normal neuromuscular an cardiac function
- Maintained by the cellular sodium-potassium pump
- K+ changes altered excitability of muscles
- Eliminated by kidneys
  - renal problems causes hyperkalemia
  - **Insulin**: causes K+ to move from ECF ICF
  - **Acidosis, trauma to cells, and exercise**
    - cause K+ to move from ICF ECF:

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Hyperkalemia
K+ > 5.5 mEq/L

- Major Causes
  - Increased potassium intake
    - excess or rapid delivery of K+
    - penicillin containing K+
    - Massive blood transfusion with irradiated packed red cells
      Buntain and Pabari (1999)
  - Shift of K+ from the ICF to ECF
    - Acidosis, uncontrolled DM
    - increased cell lysis (e.g. cytotoxic drugs)
  - Decreased renal excretion
    - Digitalis toxicity, renal failure, overuse of potassium sparing diuretics (spiroaldactone)

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Hyperkalemia
K+ > 5.5 mEq/L

- Mainfestations:
  - weak skeletal muscles/ paralysis > 8 mEq/L
  - paresthesias
  - irritability
  - abdominal cramping with diarrhea
  - irregular pulse → EKG changes → cardiac standstill
  - EKG changes
    - peaked T-waves and a shortened QT interval occur
    - Depressed ST segment and widened QRS interval

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Hyperkalemia
K+ > 5.5 mEq/L

Management

- Eliminate K+
  - Diuretics (Lasix)
  - Dialysis
  - Kayexalate
  - Increased fluids
- IV insulin
- Cardiac monitor

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Hypokalemia
K+ < 3.5 mEq

- Major causes
  - < intake of potassium or > cellular uptake of potassium
    - Insulin: promotes K+ uptake by muscle & liver cells
    - When insulin is given: K+ goes into ICF → < serum K+ level
  - Uncontrolled diabetes mellitus:
    - > Glucose: osmotic diuretic → > potassium via urinary excretion
    - Diabetic Ketoacidosis: → H+ ions in ECF → exchange across cell membranes → K+ is first elevated and then K+ stores are excreted via urine

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Hypokalemia
K+ < 3.5 mEq

- Epinephrine: promotes uptake into cells
  - stress, acute illness, hypoglycemia
- Excessive GI loss: diarrhea & ng suction metabolic alkalosis
- Diuretics: Lasix (watch K+ levels)
- Excessive renal excretion elevated aldosterone diuresis

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Hypokalemia
K+ < 3.5 mEq

- Signs & Symptoms
  - **Muscle weakness: hypotonia**
  - **Cardiac dysrhytmias (T-wave inversion or PVCs)**
  - **Atony of smooth muscle**
    - **intestinal distention**
    - **constipation**
    - **paralytic ileus**
    - **urinary retention**
  - **Confusion or disorientation**

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Hypokalemia
K+ < 3.5 mEq

Management

- Administer KCL slowly and accurately
  - dilute properly with other IV fluids
    - 10 mEqs/1 hour
  - can cause pain and necrosis of veins
    - use central IV line for large rapid amounts
- Bring pt out of immediate danger & restore gradually
- Consider discontinuing diuretic therapy
- Consider chloride for metabolic alkalosis

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Calcium
8.8 - 10 mg/dL

- Major functions:
  - Transmission of nerve impulses
  - Cardiac muscle contractions
  - Blood clotting factor
  - Formation of teeth & bone
  - Muscle contraction
- Requires:
  - Vitamin D
  - Parathyroid hormone (PTH)
  - Calcitonin from thyroid gland

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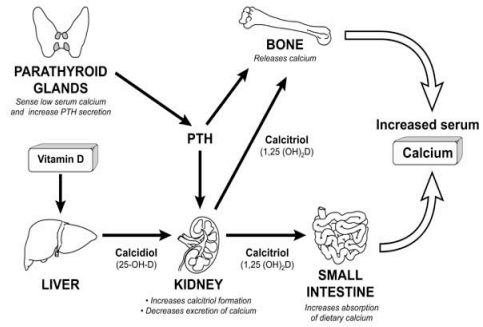

http://lpi.oregonstate.edu/infocenter/minerals/calcium/capth.html

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Hypocalcemia
Ca+ < 8.5 mg/dL

- Nutritional deficiency of calcium or Vitamin D
- Parathyroid deficiency d/t surgical removal
- Children & elderly d/t dietary deficiency
- Bone cancer: excess bone formation
  - "Hungry Tumor" syndrome
  - Treatment of prostrate cancer with estrogen depletes ECF calcium levels
- Blood transfusions
  - preserve blood with citrate & this binds with calcium

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Hypocalcemia
Ca+ < 8.5 mg/dL

- Manifestations:
  - Chvostek's sign
  - Trousseau's sign
  - Dysrythmias:< threshold for depolarization in cardiac cells
  - Paresthesias: "pins & needles"
  - Abdominal cramping & diarrhea
  - Tetany, Seizures (severe hypocalcemia)

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Hypercalcemia
Ca+ > 10.5 mg/dL

- Malignancies or hyperparathyroidism
  - PTH secreting tumor (adenoma)
- Skeletal calcium secreted into bloodstream
  - Metastatic breast cancer & multiple myeloma
- Prolonged immobility: loose Ca+ from bone into blood
- Osteoporosis: Ca+ is liberated into bloodstream
- Manifestations:
  - lethargy/ weakness/fatigue/constipation
  - pathogenic fractures calcium loss from bone

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Phosphate (PO4 -)
3.0 - 4.5mg/dL or 1.8 - 2.6 mEq/L

- **Stored with Ca+ in bones & teeth**
  - **PO-4 & Ca+ are equilibrated**
    - **> Ca+ = < PO-4**
    - **excreted by kidneys**
- **Hypophosphatemia: < 2.7 mg/dL**
  - **clinical manifestations**
    - **confusion, weakness, seizures, numbness, coma**
- **Hyperphosphatemia: > 4.5 mg/dL**
  - **common in renal failure**

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Magnesium (Mg+)
1.5 - 2.5 mEq/L

- **Second most abundant ICF cation**
  - **essential for neuromuscular function**
  - **changes in serum Mg+ levels effect other electrolytes**
- **Hypermagnesemia: > 2.5mEq/L**
  - **muscle weakness, bradycardia, hypotension, nausea & vomiting**
- **Hypomagnesemia:< 1.5mEq/L**
  - **increased neuromuscular irritability**
    - **Muscle spasms, tetany, seizures**

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