Fluids and Electrolytes

1. Fluid loss
   a. Insensible - surface areas  Infant > adult
   b. Sensible

2. Compartments
   a. Intracellular - 40%
   b. Extracellular- 20%
      1. Intravascular (plasma) 25%
      2. Interstitial 75%
   c. Transcellular fluid -
      spinal fluid, lymph, eyes

3. Distribution (varies with age)
   a. Infants--80% of weight is H₂O
   b. Premature - 90%
   c. Adult- (70 kg) 60%
   d. Skeletal muscle cells > fat cells (obese adult may have water content of 45%)
   e. Skeletal muscle mass decline with age and fat increases (less H₂O and more wt)

4. Movement of fluids
   a. Isotonic
   b. Hypotonic
   c. Hypertonic
   d. Diffusion
      1. Passive
      2. Active - requires energy
      e. Osmosis
   f. Hydrostatic pressure
   g. Colloid osmotic pressure (COP)
      1. Albumin
      2. Capillaries

5. Maintaining Balance
   a. Kidneys
      1. Nephron - filters 125 ml/min
      2. Capillary blood pressure
      3. Must excrete 20 ml/hr to eliminate wastes
      4. Children excrete higher rate than adults
         a. Children higher metabolism rate, produce more waste
         b. Can’t concentrate urine until 3 mos old and kidney remain less efficient until 2 years
      5. Kidney filter 180 L/day (GFR) and reabsorb 178 L/day
   b. ADH
      1. Vasopressin
      2. Keeps fluid levels in balance
      3. Increase serum osmolality or decrease blood volume stimulates release of ADH
      4. Decrease S.O. or increase blood volume inhibits ADH
c. **Renin and Angiotensin**
   1. Helps maintain sodium and water balances
   2. Maintains blood volume and blood pressure
   3. Glomerulus secretes enzyme renin
   4. More renin secreted if,
      a. Decrease blood flow to kidney
      b. Decrease in sodium to Glomerulus drops
   5. Renin secretion decreases in the opposite of a & b

d. **Aldosterone**
   1. Helps maintain BP and fluid balance
   2. Regulates reabsorption of sodium and \(H_2O\) in nephron
   3. Active transport of sodium from distal tubules and collecting ducts into blood stream thus more \(H_2O\) reabsorbed.

e. **Atrial natriuretic peptide**
   1. A cardiac hormone (ANP)
   2. Store in atria
   3. Released when atrial pressure increases
   4. Oppose renin - angiotensin system
      a. Decrease BP
      b. Reduces intravascular volume
   5. This powerful hormone:
      a. Suppresses serum renin levels
      b. Decreases aldosterone release by the adrenal glands
      c. Increases glomerular filtration, which increases urinary excretion of sodium and water
      d. Decreases ADH release by the posterior pituitary gland
      e. Reduces vascular resistance by causing vasodilation

6. **Types of solutions:**
   a. **Crystalloids**
      1. Isotonic
      2. Hypotonic
      3. Hypertonic
   b. **Colloids (hypertonic only)**
   c. **Crystalloids** are small molecules that flow easily from blood stream into cells.
      1. Isotonic has same concentration of osmotically active particles as extracellular fluid
      2. Hypotonic has less
      3. Hypertonic has more
      4. Hypotonic can cause cells to swell
      5. Hypertonic can cause cells to shrink
   d. **Colloids**
      1. Pulls fluid into bloodstream
      2. Albumin - protein
         a. 5% Albumin solu - osmotically equal to plasma
         b. 25% Albumin solu - draws four times, volume of fluid into circulation from interstitial in 15 minutes

**Children < 2 years**
1. Children dehydrate quickly because:
   a. Large surface area to volume
   b. Inability of kidneys to concentrate urine
   c. Fat > muscle mass
   d. Metabolic rate higher
Blood Typing

ABO typing identifies two antigens on RBC, A and B.

1. Person with A & B antigen is type AB
   a. 5% population
   b. Don’t have antibodies for A or B
   c. Called universal recipients, can receive O, A, B, or AB

2. Person with A antigen has B antibodies
   a. 85% of population has A or O
   b. Can only receive A type blood

3. Person with B antigen has A antibodies
   a. Can receive only type B
   b. 10% population

4. Person with O type has neither A or B antigens, have both A & B antibodies
   a. Universal donor - can be transfused into any type
   b. Can receive only O type blood

5. Rh antigen found in membrane of RBC
   a. 85% population, Rh positive
   b. Rh negative, has no antigen

6. No natural antibodies exist to Rh antigen

7. Rh negative person forms antibodies if exposed to Rh positive antigen

Blood Products

1. Whole blood
   a. 500 ml bag
   b. Used to treat hemorrhage, trauma, burns
   c. Stored whole blood high in potassium after 24 hrs
   d. ABO compatibility and Rh matching required

2. Packaged cells (RBC)
   a. 90% of plasma removed
   b. Anticoagulant added
   c. 250 ml bag
   d. Used to restore RBC to carry O₂
   e. 70% leukocytes removed, reduces febrile reaction
   f. ABO compatibility and Rh matching required

3. Fresh frozen plasma
   a. Plasma separated from RBC and frozen
   b. Containing protein, fibrinogen, clotting, factors, electrolytes, minerals, vitamin, hormones and antibodies
   c. ABO compatibility unnecessary Rh matching preferred
COMPARING FLUID TONICITY

The illustrations below show the effects of different types of I.V. fluids on fluid movement and cell size.

<table>
<thead>
<tr>
<th>Isotonic</th>
<th>Hypertonic</th>
<th>Hypotonic</th>
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<tbody>
<tr>
<td>Isotonic fluids such as normal saline solution have a concentration of dissolved particles, or tonicity, equal to that of the intracellular fluid. Osmotic pressure is therefore the same inside and outside the cells, so they neither shrink nor swell with fluid movement.</td>
<td>Hypertonic fluid has a tonicity greater than that of intracellular fluid, so osmotic pressure is unequal inside and outside the cells. Dehydration or rapidly infused hypertonic fluids, such as 3% saline or 50% dextrose, draw water out of the cells into the more highly concentrated extracellular fluid.</td>
<td>Hypotonic fluids such as half-normal saline solution have a tonicity less than that of intracellular fluid, so osmotic pressure draws water into the cells from the extracellular fluid. Severe electrolyte losses or inappropriate use of I.V. fluids can make body fluids hypotonic.</td>
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Isotonic solutions, such as dextrose 5% in water (D5W), have an osmolality (or concentration) of about 275 to 295 mOsm/L. The dextrose metabolizes quickly, though, leaving water behind and acting like a hypotonic solution. Large amounts of the solution may cause hyperglycemia.

Normal saline solution, another isotonic solution, contains only the electrolytes sodium and chloride. Other isotonic fluids are more similar to extracellular fluid. For instance, Ringer’s solution contains sodium, potassium, calcium, and chloride. Lactated Ringer’s solution contains those electrolytes plus lactate, which the liver converts to bicarbonate.

Hypertonic solutions are those that have an osmolality greater than 295 mOsm/L. Examples include:
- dextrose 5% in half-normal saline solution
- dextrose 5% in normal saline solution
- dextrose 5% in lactated Ringer’s solution
- dextrose 10% in water

A hypertonic solution draws fluids from the intracellular space, causing cells to shrink and the extracellular space to expand. Patients with cardiac or renal disease may be unable to tolerate extra fluid. Be alert for fluid overload and possibly pulmonary edema.

Since hypertonic solutions draw fluids from cells, patients at risk for cellular dehydration (diabetics in ketoacidosis, for example) should not receive them.

Hypotonic fluids are those fluids that have an osmolality less than 275 mOsm/L. Examples of hypotonic fluids include:
- 0.45% sodium chloride or half normal saline solution
- 0.33% sodium chloride solution
- dextrose 2.5% in water

Hypotonic solutions should be given cautiously since fluid moves from the extracellular space into cells, causing them to swell. That fluid shift can cause cardiovascular collapse from vascular fluid depletion. It can also cause increased intracranial pressure (ICP) from fluid shifting into brain cells.

Hypotonic solutions should not be given to a patients at risk for increased ICP- for example, those who have had a stroke, head trauma, or neurosurgery. Signs of increased ICP include a change in the patient’s level of consciousness, motor or sensory deficits, and changes in the size, shape, or response to light in the pupils. Hypertonic solutions also shouldn’t be used in patients who suffer from abnormal fluid shifts into the interstitial space or the body cavities, such as those that occur in liver disease, after a burn, or as a result of trauma.
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