Introduction of IV Fluid and Blood transfusion

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Water and its functions:

- Water is a transparent, tasteless, odorless, and nearly colorless chemical substance. It is vital for all known forms of life, even though it provides no calories or organic nutrients.

- Your body uses water in all its cells, organs, and tissues to maintain some functions. Major disturbances in fluid and electrolyte balance can rapidly alter cardiovascular, neurological, and neuromuscular functions, and anesthesia providers must have a clear understanding of normal water and electrolyte physiology.

- Functions:
Regulates body temperature

Lubricates joints

Moistens tissues such as those in the mouth, eyes and nose

Protects body organs and tissues

Helps prevent constipation

Lessens the burden on the kidneys and liver by flushing out waste products

Helps dissolve minerals and other nutrients to make them accessible to the body

Carries nutrients and oxygen to cells
TBW and Body Fluid Compartments

- Total body water (TBW) is the amount of sodium-free water in the whole body.
- In physiology, body water is the water content of an animal body that is contained in the tissues, the blood, the bones and elsewhere. The percentages of body water contained in various fluid compartments add up to total body water (TBW).

commonly divided into: (Body Fluid Compartments) ... And they are separated by a water-permeable membrane.

1- extracellular fluid (ECF) space (1/3 of TBW):
   a) Interstitial fluid (3/4 of ECF)
   b) Intravascular fluid/plasma (1/4 of ECF)
   c) Transcellular fluid (0.5 litre)

2- intracellular fluid (ICF) space (2/3 of TBW)
Variation in TBW

The percentages that were mentioned in the last slide were in general / adults  .. And there are some variation to be considered :

1) variation due to sex
55-60% of the BW in men and 45-50% in young women (primarily due to differences in amounts of adipose tissue)

2) Variation due to Age
Neonates contain more water than adults: 75-80% water with proportionately more extracellular fluid (ECF) then adults. At birth, the amount of interstitial fluid is proportionally three times larger than in an adult. By the age of 12 months, this has decreased to 60% which is the adult value.

Total body water as a percentage of total body weight decreases progressively with increasing age. By the age of 60 years, total body water (TBW) has decreased to only 50% of total body weight in males mostly due to an increase in adipose tissue.
3) Variation between Tissues
Most tissues are water-rich and contain 70-80% water. The three major exceptions to this are:
Plasma: 93% water (& 7% 'plasma solids')
Fat: 10-15% water
Bone: 20% water

4) Variation between Individuals
The variation between individuals in the ratio of TBW to total body weight is quite large but the majority of the variation is due to different amounts of adipose tissue as adipose has a low water content. Differences (between individuals) in the amount of bone and plasma are much smaller. Obese adults have a lower ratio because of the greater amount of adipose tissue. Differences in percent body water between males and females are primarily due to differences in amounts of adipose tissue. For any particular tissue of the body the variation is very much less but any variation that occurs is still mostly due to differences in amount of fat content.
Calculation:

- TBW = percentage * body weight
- example:

  - Total Body Water (TBW)
    - (70Kg man)
    - 42 litres

  - Extracellular Fluid Volume (ECF)
    - 1/3 of Total Body Weight = 14 Litres

  - Intracellular Fluid Volume (ICF)
    - 2/3 of Total Body Weight = 28 Litres

  - Interstitial Fluid
    - 3/4 of ECF = 10.5 Litres

  - Plasma
    - 1/4 of ECF = 3 Litres

  - Transcellular Fluid
    - 0.5 Litre
Electrolytes:

- The volume of fluid (water) within each compartment is determined by its solute composition and concentrations (The main extracellular electrolyte is Na and the main intracellular electrolyte is K).
- Differences in solute concentrations are largely due to the characteristics of the physical barriers that separate compartments.
- The osmotic forces created by “trapped” solutes govern the distribution of water between compartments and ultimately each compartment’s volume.

- Osmotic pressure: the pressure that would have to be applied to a pure solvent to prevent it from passing into a given solution by osmosis, often used to express the concentration of the solution.
<table>
<thead>
<tr>
<th>Extracellular Fluid</th>
<th>Intracellular Fluid</th>
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<tbody>
<tr>
<td><strong>Na⁺</strong> 142 mEq/L</td>
<td><strong>K⁺</strong> 10 mEq/L</td>
</tr>
<tr>
<td><strong>K⁺</strong> 4 mEq/L</td>
<td><strong>Ca²⁺</strong> 140 mEq/L</td>
</tr>
<tr>
<td><strong>Ca²⁺</strong> 5 mEq/L</td>
<td><strong>Mg²⁺</strong> &lt;1 mEq/L</td>
</tr>
<tr>
<td><strong>Mg²⁺</strong> 3 mEq/L</td>
<td><strong>Cl⁻</strong> 58 mEq/L</td>
</tr>
<tr>
<td><strong>Cl⁻</strong> 103 mEq/L</td>
<td><strong>HCO₃⁻</strong> 4 mEq/L</td>
</tr>
<tr>
<td><strong>HCO₃⁻</strong> 28 mEq/L</td>
<td><strong>Phosphates</strong> 10 mEq/L</td>
</tr>
<tr>
<td><strong>Phosphates</strong> 4 mEq/L</td>
<td><strong>S₀₄⁻</strong> 75 mEq/L</td>
</tr>
<tr>
<td><strong>S₀₄⁻</strong> 1 mEq/L</td>
<td><strong>Osmolality</strong> 281 mOsm/L</td>
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</tbody>
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**Osmolality** 281 mOsm/L
The outer membrane of cells plays an important role in regulating intracellular volume and composition.

A membrane-bound adenosine triphosphate (ATP)-dependent pump exchanges Na+ for K+ in a 3:2 ratio.

Because cell membranes are relatively impermeable to sodium and, to a lesser extent, potassium ions, potassium is concentrated intracellularly, whereas sodium is concentrated extracellularly. As a result, potassium is the most important determinant of intracellular osmotic pressure, whereas sodium is the most important determinant of extracellular osmotic pressure.

The impermeability of cell membranes to most proteins results in a high intracellular protein concentration (high oncotic protein). Because proteins act as nondiffusible solutes (anions), the unequal exchange ratio of 3 Na+ for 2 K+ by the cell membrane pump is critical in preventing relative intracellular hyperosmolality. Interference with Na+-K+ -ATPase activity, as occurs during ischemia or hypoxia, results in progressive swelling of cells.
EXTRACELLULAR FLUID

The principal function of ECF is to provide a medium for delivery of cell nutrients and electrolytes and for removal of cellular waste products.

Maintenance of a normal extracellular volume—particularly the circulating component (intravascular volume)—is critical.

For the reasons described earlier, sodium is quantitatively the most important extracellular cation and the major determinant of extracellular osmotic pressure and volume.

Changes in ECF volume are therefore related to changes in total body sodium content. The latter is a function of sodium intake, renal sodium excretion, and extrarenal sodium losses (vomiting /diarrhea/sweating /third space sequestration)

Extracellular fluid is composed of:
1) Interstitial Fluid

Very little interstitial fluid is normally in the form of free fluid. Most interstitial water is in chemical association with extracellular proteoglycans, forming a gel.

Interstitial fluid pressure is generally thought to be negative (approximately -5 mm Hg).

Increases in extracellular volume are normally proportionately reflected in intravascular and interstitial volume. However, as interstitial fluid volume progressively increases, interstitial pressure also rises and eventually becomes positive. When the latter occurs, free fluid in the interstitial gel matrix increases rapidly and the result is expansion only of the interstitial fluid compartment.

In this way, the interstitial compartment acts as an overflow reservoir for the intravascular compartment, as seen clinically in tissue edema.

Overflow reservoir for the intravascular compartment, only small quantities of plasma proteins can normally cross capillary clefts, the protein content of interstitial fluid is relatively low (2 g/dL). Protein entering the interstitial space is returned to the vascular system via the lymphatic system.
2) Intravascular Fluid

Intravascular fluid, commonly referred to as plasma, is restricted to the intravascular space by the vascular endothelium. Most electrolytes (small ions) freely pass between plasma and the interstitium, resulting in nearly identical electrolyte composition.

However, the tight intercellular junctions between adjacent endothelial cells impede the passage of plasma proteins to outside the intravascular compartment. As a result, plasma proteins (mainly albumin) are the only osmotically active solutes in fluid not normally exchanged between plasma and interstitial fluid.
3) Transcelullar fluid:

Transcellular fluid is the portion of TBW contained within epithelial lined spaces. It is the smallest component of extracellular fluid, e.g.: cerebrospinal fluid, and ocular fluid, joint fluid.
The normal adult daily water intake averages 2500 mL, which includes approximately 300 mL as a byproduct of the metabolism of energy substrates.

Daily water loss averages 2500 mL and is typically accounted for by:
- 1500 mL in urine,
- 400 mL in respiratory tract evaporation,
- 400 mL in skin evaporation,
- 100 mL in sweat,
- 100 mL in feces.

Evaporative loss is very important in thermoregulation because this mechanism normally accounts for 20% to 25% of heat loss.

Both ICF and ECF osmolalities are tightly regulated to maintain normal water content in tissues. Changes in water content and cell volume may induce significant impairment of function, particularly in the brain.
it's important to rehydrate by drinking fluids and eating foods that contain water.

The amount of water you need depends on a variety of factors, including:
1) the climate you live in,
2) how physically active you are
3) whether you're experiencing an illness or have any other health problems.
Nomenclature of solutions

- the quantity of a solute in a solution may be expressed in grams, moles, or equivalents.
- the concentration of a solution may be expressed either as
  1) quantity of solute per volume of solution
  2) quantity of solute per weight of solvent.
Molarity, Molality, & Equivalency

- One mole (mol) of a substance represents $6.02 \times 10^{23}$ molecules.
- **Molarity** is the standard SI unit of concentration that expresses the number of moles of solute *per liter of solution* (mol/L, or M).
- **Molality** is an alternative term that expresses moles of solute *per kilogram of solvent*.
- Equivalency is also commonly used for substances that ionize: The number of equivalents of an ion in solution is the number of moles multiplied by its charge (valence). Eg: a 1 M solution of MgCl\(_2\) yields 2 equivalents of magnesium per liter and 2 equivalents of chloride per liter.
Osmolarity, Osmolality, & Tonicity

Osmosis is the net movement of water across a semipermeable membrane as a result of a difference in nondiffusible solute concentrations between the two sides.

Osmotic pressure is the pressure that must be applied to the side with more solute to prevent a net movement of water across the membrane to dilute the solute. Generally dependent only on the number of nondiffusible solute particles. This is because the average kinetic energy of particles in solution is similar regardless of their mass.

One osmole (Osm) equals 1 mol of nondissociable substances.

For substances that ionize, each mole results in n Osm, where n is the number of ionic species produced.

The osmolarity of a solution is equal to the number of osmoles per liter of solution.

The osmolality equals the number of osmoles per kilogram of solvent.

Tonicity, a term that is often used interchangeably with osmolarity and osmolality, refers to the effect a solution has on cell volume. An isotonic solution has no effect on cell volume, whereas hypotonic and hypertonic solutions increase and decrease cell volume.
Thank you 😊