Volum

Body Fluid Compartments

- Total Body Water (TBW): 50-70% of total body wt.
- Avg. is greater for males.
- Decreases with age. Highest in newborn, 75-80%. By first year of life TBW ~ 65%.
- Most in muscle, less in fat.
- TBW= ECF + ICF
- ICF ~ 2/3 & ECF ~ 1/3
- ECF = Intravascular (1/3) + Interstitial (2/3)

Electrolyte Physiology

- Primary intravascular/ECF cation is Na^+. Very small contribution of K^+, Ca^{2+}, and Mg^{2+}.
- Primary intravascular/ECF anion is Cl^-. Smaller contribution from HCO_3^-, SO_4^{2-} & PO_4^{3-}, organic acids, and protein.
- Primary ICF cation is K^+. Smaller contribution from Mg^{2+} & Na^+.
- Number of intravasc anions not routinely detected.

ICF (mEq/L)	ECF (mEq/L)
Cations	
K^+ (150-154)	Na^+ (142)
Na^+ (6-10)	Ca^{+2} (5)
Mg^{+2} (40)	K^+ (4-5)
	Mg^{+2} (3)
Anions	
Organic PO_4^{-3} (100-106)	Cl^- (103-105)
protein (40-60)	HCO_3^- (24-27)
SO_4^{-2} (17)	protein (15)
HCO_3^- (10-13)	PO_4^{-3} (3-5), SO_4^{-2} (4)
organic acids (4)	Organic acids (2-5)

Table 2-1
Water Exchange (60- to 80-kg Man)

Routes	*Average Daily Volume (mL)*	*Minimal, (mL)*	*Maximal, (mL)*
H_2O gain:			
Sensible:			
Oral fluids	800–1500	0	1500/h
Solid foods	500–700	0	1500
Insensible:			
Water of oxidation	250	125	800
Water of solution	0	0	500
H_2O loss:			
Sensible:			
Urine	800–1500	300	1400/h
Intestinal	0–250	0	2500/h
Sweat	0	0	4000/h
Insensible:			
Lungs and skin	600	600	1500

Table 2 Daily Electrolyte Requirements

	DAILY REQUIREMENT	FOR 70-KG ADULT	FOR 10-KG CHILD
Sodium	1-2 meq/kg	70-140 meq/day	10-20 meq/day
Potassium	0.5-1.0 meq/kg	35-70 meq/day	5-10 meq/day
Calcium	0.2-0.3 meq/kg	1.4-2.1 meq/day	2.0-3.0 meq/day
Magnesium	0.35-0.45 meq/kg	24.5-31.5 meq/day	3.5-4.5 meq/day
Chloride	equal to sodium	equal to sodium	equal to sodium
Bicarbonate/Acetate	use with chloride to balance cations and help pH	use with chloride to balance cations and help pH	use with chloride to balance cations and help pH

IV Fluid/Electrolyte Therapy

- Three key concepts in consideration of fluid and electrolyte management:
- cell membrane permeability
- osmolarity
- electroneutrality

Cell membrane permeability refers to the ability of a cell membrane to allow certain substances such as water and urea to pass freely, while charged ions such as sodium cannot cross the membrane and are trapped on one side of it.

Osmolarity

- Osmolarity is a property of particles in solution. If a substance can dissociate in solution, it may contribute more than one equivalent to the osmolarity of the solution. For instance, NaCl will dissociate into two osmotically active ions: Na and Cl. One millimolar NaCl yields a 2 milliosmolar solution.

Electroneutrality

- Electroneutrality means that the overall number of positive and negative charges balances. For instance, in conditions like renal tubular acidosis where HCO_3^- is lost, chloride is retained leading to a hyperchloremic state.

"Expected osmolarity of plasma can..."

- Expected osmolarity of plasma can be calculated according to the following formula:

Osmolarity (mOsm/kg) = 2×[mEq/L Na+] + glucose + BUN

- Concentration of sodium is the major determinant.

Normal serum osmolarity ranges from about 280 to 295 mOsm/kg.

Maintenance fluids must be determined for basic requirements, then existing volume or electrolyte deficits must be evaluated to determine the appropriate IV fluid to use and the volume to administer.

Types of IV Fluid

- Crystalloid
- Colloid

Crystalloid:

- Balanced salt/electrolyte solution; forms a true solution and is capable of passing through semipermeable membranes. May be isotonic, hypertonic, or hypotonic.
- Normal Saline (0.9% NaCl), Lactated Ringer’s, Hypertonic saline (3, 5, & 7.5%), Ringer’s solution.
- However, hypertonic solutions are considered plasma expanders as they act to increase the circulatory volume via movement of intracellular and interstitial water into the intravascular space.

Colloid:

- Colloid: High-molecular-weight solutions, draw fluid into intravascular compartment via oncotic pressure (pressure exerted by plasma proteins not capable of passing through membranes on capillary walls). Plasma expanders, as they are composed of macromolecules, and are retained in the intravascular space.
- HAES, Gelatina (Dextran);
- Albumin, Plasma

"Free H2O solutions:"

- Free H2O solutions: provide water that is not bound by macromolecules or organelles, free to pass through.
- D5W (5% dextrose in water), D10W, D20W, D50W, and Dextrose/crystalloid mixes.

"IVF can supply 3 things"

- fluid,
- electrolytes,
- calories (150 ml/h D5W)

The most common uses for IVF:

- Acutely expand intravascular volume in hypovolemic states
- Correct electrolyte imbalances
- Maintain basal hydration

infusion:

- Ringer's lactate solution
- NaCl 0,9

Normal Saline (0.9% NaCl):

- Isotonic salt water.
  154 mEq/L Na+; 154 mEq/L Cl-; 308mOsm/L.
  Cheapest and most commonly used resuscitative crystalloid.
- High [Cl-] above the normal serum 103 mEq/L imposes on the kidneys an appreciable load of excess Cl- that cannot be rapidly excreted. A **dilutional acidosis** may develop by reducing base bicarb relative to carbonic acid. Thus exist the risk of hyperchloremic acidosis. Only solution that may be administered with blood products. Does not provide free water or calories. Restores NaCl deficits

Lactated Ringer's solution

- isotonic, beginning of volume resuscitation

Ingredients:

* 130 mEq of sodium ion.
* 109 mEq of chloride ion.
* 28 mEq of lactate.
* 4 mEq of potassium ion.
* 3 mEq of calcium ion.

Lactate is converted readily to bicarb by the liver. Has minimal effects on normal body fluid composition and pH. More closely resembles the electrolyte composition of normal blood serum. Does not provide calories.

"Volume deficits are best estimated..."

Volume deficits are best estimated by acute changes in weight. Less than 5% loss is very difficult to detect clinically and loss of 15+% will be associated with severe circulatory compromise.

- Mild deficit represents a loss of ~ 4% body wt.
- Moderate deficit --- a loss of ~ 6-8% body wt.
- Severe deficit --- a loss of ~ >10% body wt.

Volume deficit may be a pure water deficit or combined water and electrolyte deficit.

Resuscitative IV Fluids

Principle of trauma & surgery: Crystalloids; isotonic balanced salt solutions. NS or RL.

Amount given based upon body wt, clinical picture, and vital signs. ?shock.

Generally a bolus of 500-2000cc is given depending on the above, then rates are run at 1.5-2x maintenance or 10-20cc/kg/d on top of maintenance. Continuous clinical r/a of vitals and response to fluids already given is required for ongoing IVF therapy.

Resuscitative IVF therapy is for initial stabilization and overlaps with further replacement therapy.

Monitoring endpoints for IVF therapy

Endpoint should be maintenance or reestablishment of homeostasis.

- In order to reestablish homeostasis in a pt, IVF therapy must not only provide a **balance of water** and

electrolytes, but must ensure adequate **oxygen delivery** to all organs and renal perfusion as evidenced by urine output.

- Endpoints: normalization of VS, UO>0.5ml/kg/hr (1ml/kg/hr for a child) and restoration of normal mental status and lack of clinical signs of deficit.
- Other endpoints include normalization of labs,