Management of Ileostomy and other GI Fluid Losses

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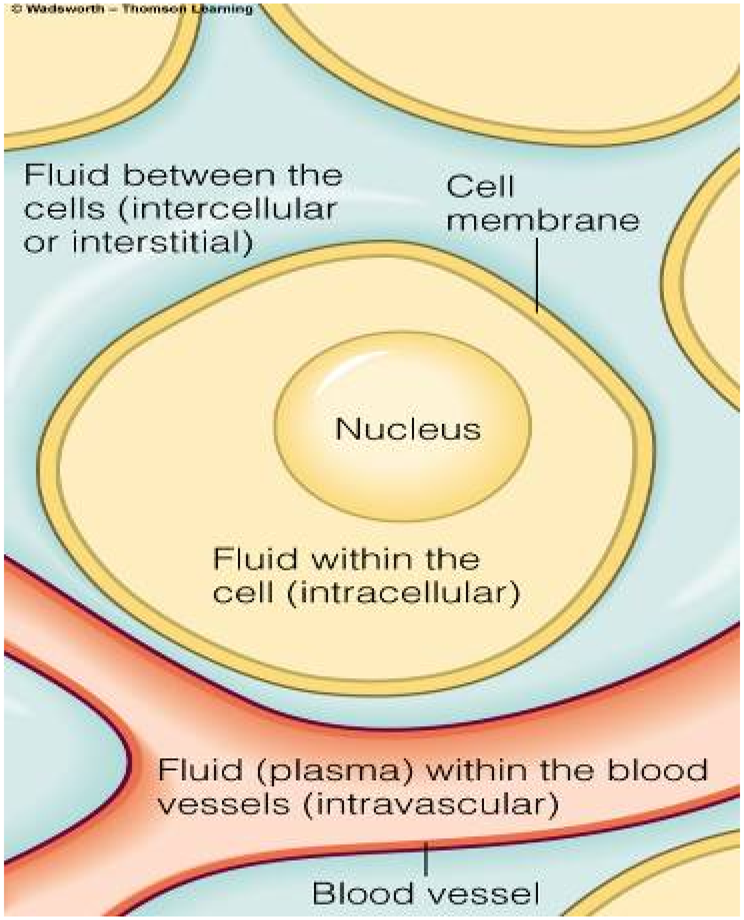
Anatomy of Body Fluids

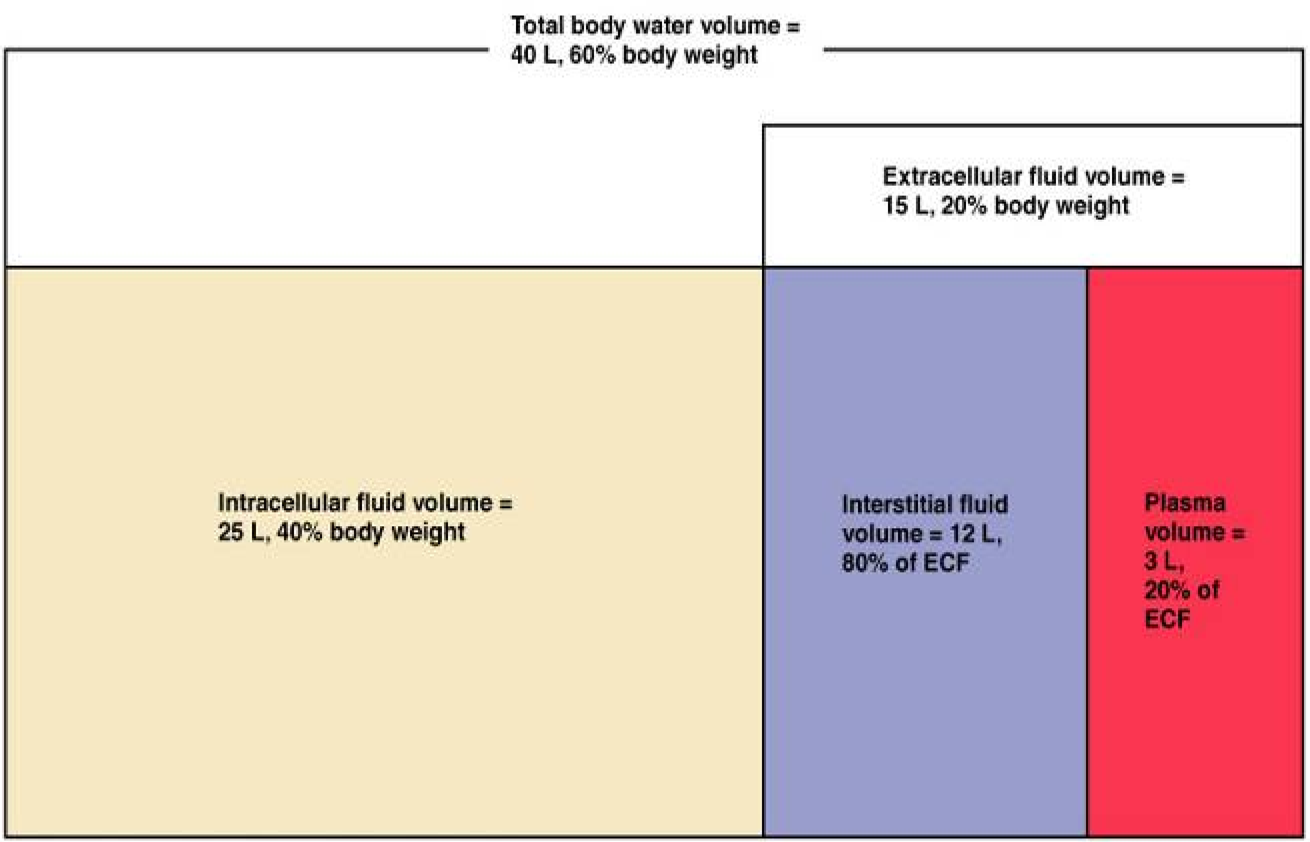
- Males: water constitutes 60% of body weight
- Females: water constitutes 50% of body weight
- Functional compartments of body fluids:
  - Intracellular space – 40% of body weight
  - Extracellular space – 20% of body weight
    - Interstital – 15%
    - Plasma – 5%

Body Compartments

40%	Dry
40%	Intracellular
15%	**Interstitial**
5%	**Plasma**



Fluid Compartments



Anatomy of Body Fluids

- Changes with age:
  - Newborns – 75-80% of body weight is water
  - One year – 65 % of body weight is water
  - Adult – males 60%, females 50%

Gamble JL: Lane Medical Lectures. Companion of water and electrolytes in the organization of body fluids. Stanford University Publication, vol V, Number 1, 1951

Intracellular Fluid Space

- 40% of body weight
- Largest proportion is in skeletal muscle
- Larger percentage of water is Intracellular in males (large muscle mass)
- Cations = Potassium & Magnesium
- Anions = Phosphates and Proteins

Extracellular Fluid Space

- 20% of body weight
  - Interstitial 15%, Plasma 5%
  - Cations = Sodium
  - Anions = Chloride and Bicarbonate
  - Has a small “nonfunctioning” component
    - Connective tissue water
    - Transcellular (CSF, Joint fluid, etc)

TABLE 12-4 Important Body Electrolytes

Electrolytes	Intracellular (inside cells) Concentration (mEq/L)	Extracellular (outside cells) Concentration (mEq/L)
Cations (positively charged ions)		
Sodium (Na^+)	10	142
Potassium (K^+)	150	5
Calcium (Ca^{++})	2	5
Magnesium (Mg^{++})	40	3
	202	155
Anions (negatively charged ions)		
Chloride (Cl^-)	2	103
Bicarbonate (HCO_3^-)	10	27
Phosphate ($HPO_4^=$)	103	2
Sulfate ($SO_4^=$)	20	1
Organic acids (lactate, pyruvate)	10	6
Proteins	57	16
	202	155

Water Balance

TABLE 12-3 Water Balance

Water Sources	Amount (mL)	Water Losses	Amount (mL)
Liquids	550 to 1500	Kidneys (urine)	500 to 1400
Foods	700 to 1000	Skin (sweat)	450 to 900
Metabolic water	200 to 300	Lungs (breath)	350
		GI tract (feces)	150
Total	1450 to 2800	Total	1450 to 2800

Normal Exchange of Fluid & Electrolytes

- Water exchange:
  - Average adult consumption is 2000 to 2500 mls per day. (1500 mls in the form of fluids)
  - Losses:
    - 250 ml in stool
    - 800 – 1500 ml in urine (minimum = 500 ml)
    - 600 ml in insensible losses
      - **Skin (75%)**
      - **Lungs (25%)**

Fluid Output Regulation

- Kidneys
  - Major regulatory organ
    - Receive about 180 liters of blood/day to filter
    - Produce 1200-1500 cc of urine
- Skin
  - Regulated by sympathetic nervous system
    - Activates sweat glands
      - Sensible or insensible-500-600 cc/day
        - Directly related to stimulation of sweat glands
- Respiration
  - Insensible
    - Increases with rate and depth of respirations, oxygen delivery
      - About 400 cc/day
- Gastrointestinal tract
  - In stool
      - Average about 100-200
        - GI disorders may increase or decrease it.

Normal Exchange of Fluid & Electrolytes

- Salt exchange:
  - Average adult consumption varies between 50 to 90 meq of Sodium Chloride per day. Balance is maintained by renal excretion of excess salt.
  - Losses occur mostly from the GI tract:
    - GI losses are usually isotonic or slightly hypotonic and should be replaced by an isotonic salt solution.
    - Note: losses of extracellular fluid represents isotonic losses of salt and water

Sodium in Fluid and Electrolyte Balance

- Sodium holds a central position in fluid and electrolyte balance
- Sodium salts:
  - Account for 90-95% of all solutes in the ECF
  - Contribute 280 mOsm of the total 300 mOsm ECF solute concentration
- Sodium is the single most abundant cation in the ECF
- Sodium is the only cation exerting significant osmotic pressure

Sodium in Fluid and Electrolyte Balance

- The role of sodium in controlling ECF volume and water distribution in the body is a result of:
  - Sodium being the only cation to exert significant osmotic pressure
  - Sodium ions leaking into cells and being pumped out against their electrochemical gradient
- Sodium concentration in the ECF normally remains stable

Regulation of Potassium Balance

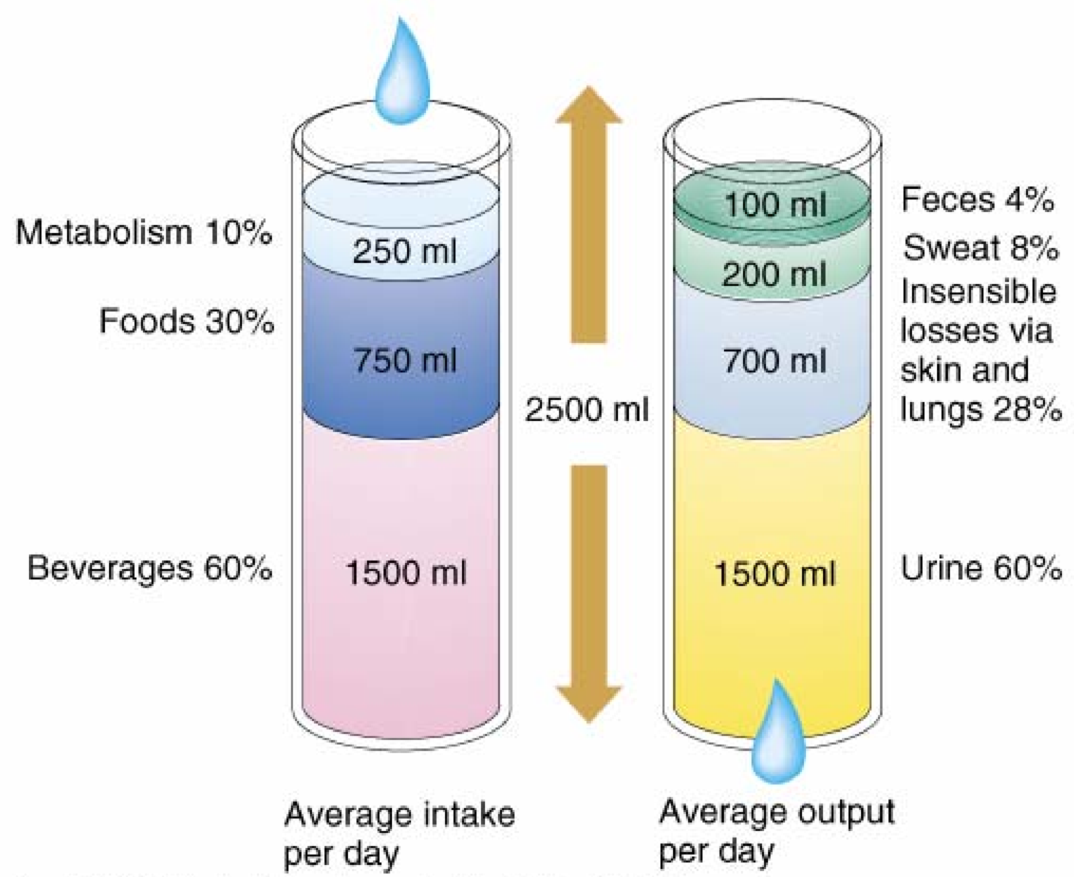
- Relative ICF-ECF potassium ion concentration affects a cell's resting membrane potential
  - Excessive ECF potassium decreases membrane potential
  - Too little K^+ causes hyperpolarization and nonresponsiveness

Regulation of Potassium Balance

- Hyperkalemia and hypokalemia can:
  - Disrupt electrical conduction in the heart
  - Lead to sudden death
- Hydrogen ions shift in and out of cells
  - Leads to corresponding shifts in potassium in the opposite direction
  - Interferes with activity of excitable cells

Water Balance: Input = Output

Urine output begins ~30 min after drinking and peaks after ~ 1 hour.



Darrow DC and Pratt EL: Fluid therapy. Relation to tissue composition and the expenditure of water and electrolyte. JAMA 1950;143:365-373 and 432-439

Gastrointestinal Secretions

Type of secretion	Volume (mL/24h)	Na (meq/L)	K (meq/L)	Cl (meq/L)	HCO_3 (meq/L)
Salivary	1500	10	26	10	30
Stomach	1500	60	10	130	
Duodenum	100 – 2000	140	80	80	
Ileum	3000	140	104	104	30
Colon/ Pancreas	100 – 800	60 / 140	30 / 5	40 / 70	/ 115
Bile	50 - 800	145	100	100	35

Extracellular Fluid Loss

- Most common cause is GI losses
  - Vomiting, diarrhea, NG losses, Fistula drainage, GI bleed
- Third space losses
  - Peritonitis, bowel obstruction, burns, etc
- Renal losses
  - Diuretics, Osmotic diuresis, etc

Clinical Assessment of Dehydration

- History
  - Vomiting, diarrhea, IV fluids (type, duration), surgery (type, duration)
- Physical examination
  - Vitals, skin turgor, tears, cap refill, JVP, Hypotension
- Urine output
  - Volume, colour

Estimation of Deficit

Severity	% Water Deficit	Clinical Signs
Minimal	<5	Thirst, mild oliguria
Mild	5	Mild tachycardia, dry mucous membranes and concentrated urine
Moderate	10	Marked tachycardia, loss of skin turgor, severe thirst, sunken eyeballs and oliguria
Severe	15	Low BP, poor circulation, CNS changes, anuria

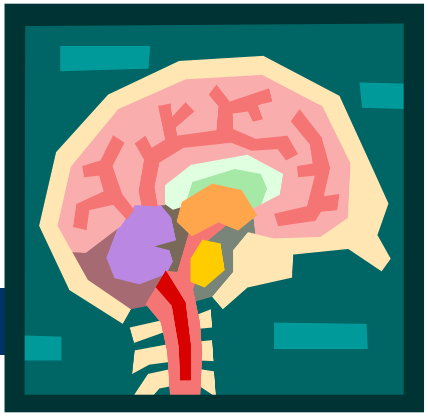
Laboratory Assessment of Dehydration

- CBC
  - Elevated hematocrit, hemoconcentration of indices
- Electrolytes
  - Sodium?, Potassium?
- Urine
  - Sodium concentration (<10 mEq/l), Osmolality,
- Other
  - BUN, Creatinine (Prerenal azotemia)

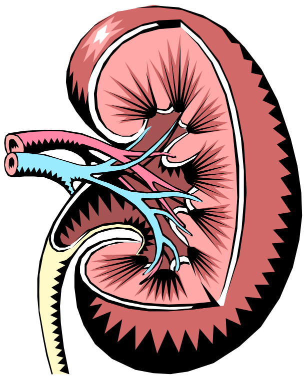
Physiologic Responses to Dehydration

1. Stimulation of antidiuretic hormone (ADH) secretion
2. Increased renin-aldosterone system
3. Decreased glomerular filtration rate

Hormonal regulation

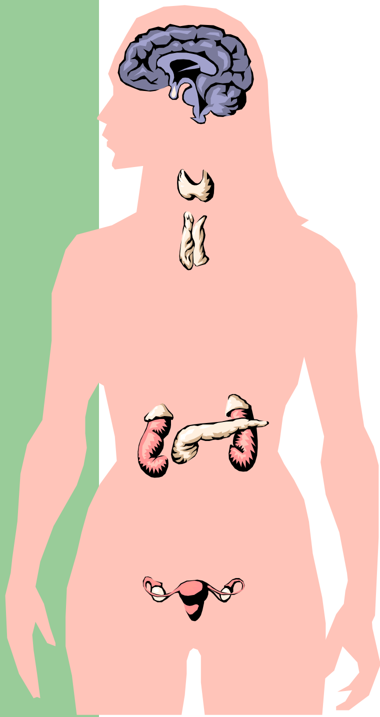


- ADH
  - Stored in posterior pituitary gland
    - Released in response to changes in blood osmolarity
    - Makes tubules and collecting ducts more permeable to water
      - Water returns the systemic circulation
        - Dilutes the blood
      - Decreases urinary output



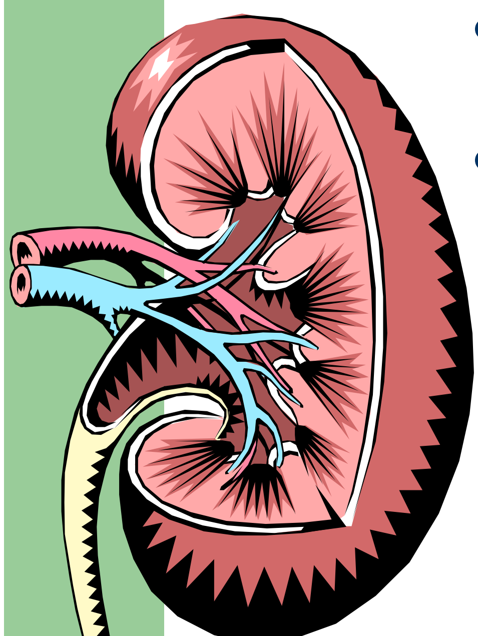
Hormonal regulation (cont)

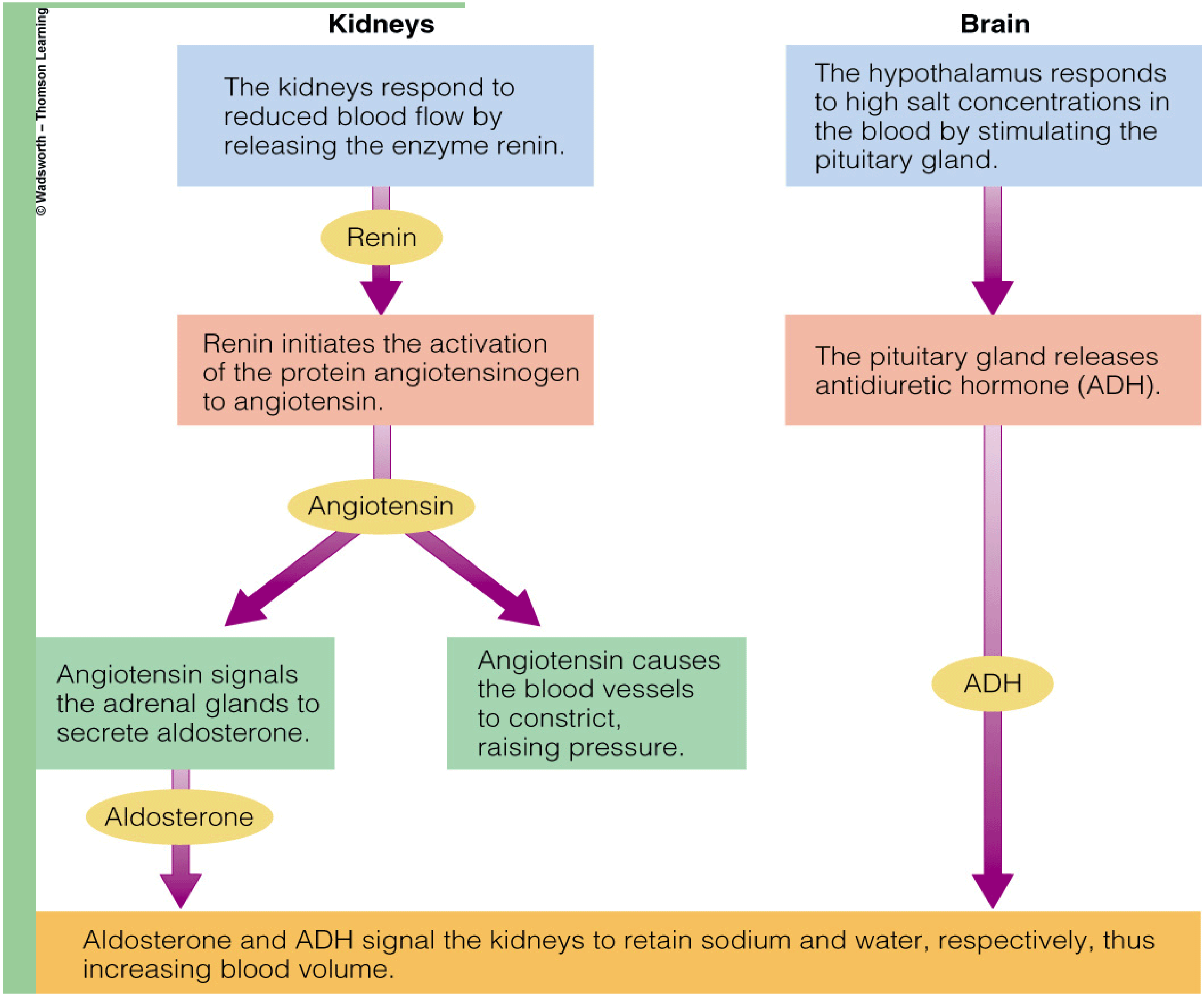
- Aldosterone
  - Released by adrenal cortex
    - In response to increased plasma potassium
    - Or as part of renin-angiotensin-aldosterone mechanism
      - Acts on distal tubules to increase reabsorption of sodium and water
      - Excretion of potassium and hydrogen



Hormonal regulation (cont)

- Renin
  - Secreted by kidneys
    - Responds to decreased renal perfusion
    - Acts to produce angiotensin I
      - Causes vasoconstriction
    - Converts to Angiotensin II
      - Massive selective vasoconstriction
        - Relocates and increases the blood flow to kidney, improving renal perfusion
      - Stimulates release of aldosterone with low sodium

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Kidneys
The kidneys respond to reduced blood flow by releasing the enzyme renin.
Renin
Renin initiates the activation of the protein angiotensinogen to angiotensin.
Angiotensin
Angiotensin signals the adrenal glands to secrete aldosterone.
Angiotensin causes the blood vessels to constrict, raising pressure.
Aldosterone
Brain
The hypothalamus responds to high salt concentrations in the blood by stimulating the pituitary gland.
The pituitary gland releases antidiuretic hormone (ADH).
ADH
Aldosterone and ADH signal the kidneys to retain sodium and water, respectively, thus increasing blood volume.

Types of Dehydration

- Isotonic Dehydration
- Hypotonic Dehydration
- Hypertonic Dehydration

Types of Dehydration (cont)

- Isotonic Dehydration
  - Most common form of dehydration
  - type of dehydration in which serum sodium concentration remains normal
  - Most GI losses are isotonic dehydration

Types of Dehydration (cont)

- Hypotonic Dehydration
  - sodium concentration is less than 130 mEq/L
  - osmotic gradients across the cell membrane forces water movement from the ECF to the ICF, causing disproportional ECF and blood volume depletion

Hypotonic Dehydration

- develops if the Na+ loss is disproportionally greater than the water loss, or if considerable amount of a hypotonic solution is given for replacement

Types of Dehydration (cont)

- Hypertonic Dehydration
  - serum sodium is greater than 150 mEq/L
  - osmotic gradients across the cell membrane forces water movement from the ICF to the ECF
  - This supports the ECF volume and masking the signs of profound dehydration

Types of Dehydration (cont)

- Hypernatremic dehydration is termed cellular dehydration, without cardiovascular collapse

- develops when usual hypotonic fluid losses are excessive, and are adequately compensated by hypotonic fluid intake and by water movement from the ICF to the ECF.

Intravenous Fluids

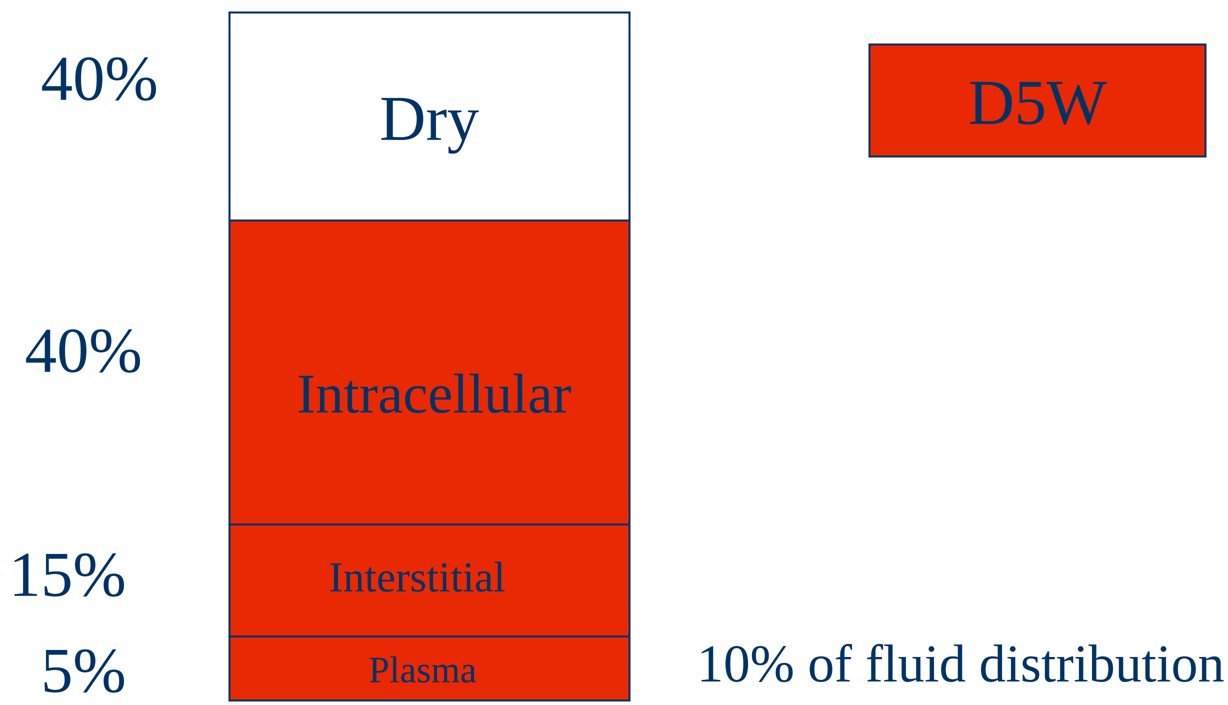
Type of Fluid	Na	K	Cl	HCO
Normal Saline	154	0	154	0
½ Normal Saline	77	0	77	0
Ringers Lactate	130	4	109	28
D5W	0	0	0	0
25% Albumin	130	0	120	0

Note: Glucose can be added to any crystalloid solution.

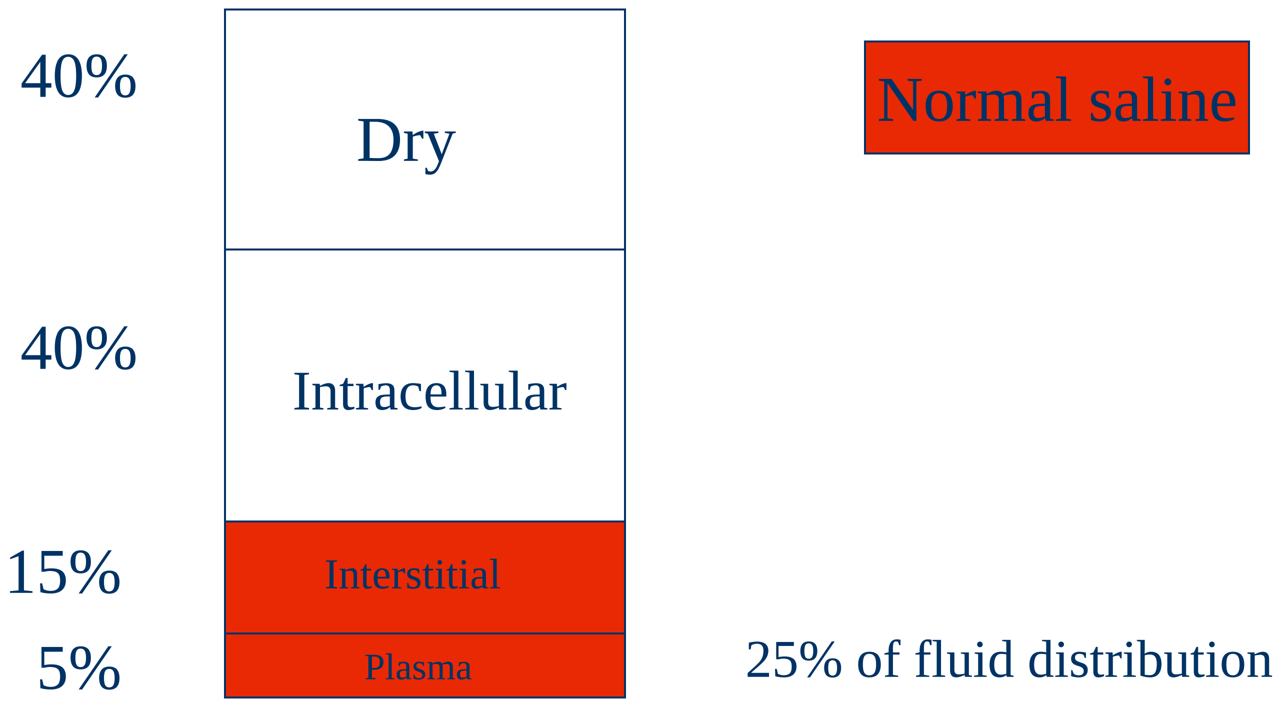
Fluid Replacement

- The solvent (water) will follow the distribution of the solute
  - Examples:
    - One liter of D5W will distribute throughout all fluid compartments and therefore less than 10% will remain in the plasma compartment.
    - One liter NS will distribute throughout the extracellular fluid compartment and 25% will remain in the plasma compartment.

Fluid Compartments



Body Compartments



Fluid Replacement

- Maintenance
  - 4/2/1   100/50/20
- Deficit
  - Actual weight loss vs estimate
  - Give ½ in first 8 hrs and ½ in next 16 hrs
- Ongoing losses
  - NG losses, fistulas, third space, etc

Ileostomy and Fluid Loss

- Normally 1 to 1.5 liters enter the colon from the ileum.
- Ileostomy output should average 10-15 mL/kg/d.
- The proximal bowel can adapt to the fluid and electrolyte losses of a distal small bowel stoma.
- After a period of adaptation, the absorptive capacity of the small bowel proximal to the ileostomy increases, and the bowel can reduce ileostomy electrolyte losses by as much as two thirds of its initial output.
- Adaptation eventually decreases the flow to average of 750ml per day
- 90% of this output is water

Ileostomy and Fluid Loss (cont)

- Ileostomy diarrhea is present when losses exceed 1000ml per day
- The small intestine unlike the colon is not able to conserve NaCl effectively
- Patients with ileostomies have an obligatory loss of 30 to 40 meq/day

Ileostomy and Fluid Loss (cont)

- Patients with ileostomies have lower Na/K ratio in urine due to renal conservation of sodium and water
- Urine composition changes predisposing to urolithiasis in patients- urate and calcium
- After ileostomy secondary bile acids disappear from bile- no metabolic consequences
- Patients with long-standing ileostomies often have hypomagnesemia and decreased absorption of vitamin B-12 and folic acid.

Ileostomy effluent content

- The flora of ileostomy effluents has quantitative (10^4 to 10^7 organisms) and qualitative charateristics that are in between fecal and normal ileal content.

Limiting stomal output

- **PPI**
  - Treatment with proton pump inhibitors in the immediate postoperative period using pantoprazole intravenously, given as an 80-mg bolus followed by an infusion at 8 mg/hour.
  - On resumption of oral intake, proton pump inhibitors are given orally twice a day as omeprazole 20 mg to suppress hypersecretion

  - 15% reduction in output (large doses)

Treatment of high output enterocutaneous fistulas with a somatostatin analogue and famotidine. Eur J Surg. 1992 Aug;158(8):443-5.

Limiting stomal output

- **Loperamide (imodium)**
  - loperamide, can be used to slow gastric and intestinal transit to 1-3 bowel movements per day.
  - 2 tablets (4 mg) initially then 2 mg after each unformed stool not to exceed 8 mg/ day (OTC dose) or 16 mg/day (prescription dose)

Short bowel syndrome: a nutritional and medical approach.
Jeejeebhoy KN - *CMAJ* - 14-MAY-2002; 166(10): 1297-302

Limiting stomal output

- **Lomotil**
  - If loperamide does not work, then codeine or diphenoxylate-atropine (**Lomotil**) may be used
  - Diphenoxylate with atropine (Lomotil) has central opiate effects, with overdose liability, atropine may cause side effects
  - 2 tablets (4 mg) q.i.d.

Limiting stomal output

- **Somatostatin /Octreotide**
  - Octreotide has been shown to decrease intestinal output by three mechanisms.

1. It inhibits the release of gastrin, cholecystokinin, secretin, motilin, and other GI hormones. This inhibition decreases secretion of bicarbonate, water, and pancreatic enzymes into the intestine, subsequently decreasing intestinal volume.

Sandostatin as a "hormonal" temporary protective ileostomy in patients with total or subtotal colectomy. Hepatogastroenterology. 2003 Sep-Oct;50(53):1367-9.

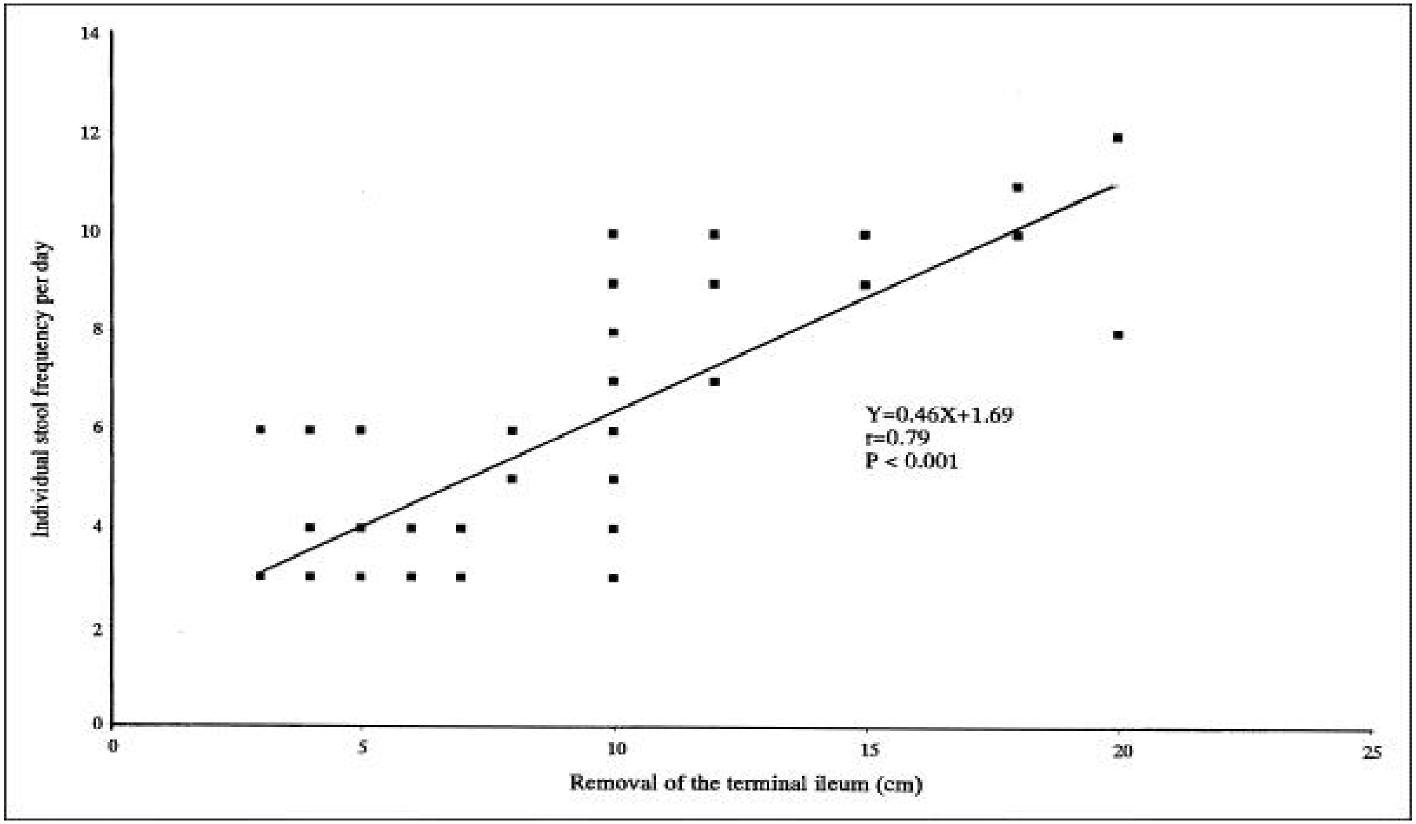
Limiting stomal output

2. octreotide relaxes intestinal smooth muscle, thereby allowing for a greater intestinal capacity.

3. octreotide increases intestinal water and electrolyte absorption

Sancho JJ, di Costanzo J, Nubiola P, et al: Randomized double-blind placebo-controlled trial of early octreotide in patients with postoperative enterocutaneous fistula. Br J Surg 82:638, 1995.

Regression line in the relationship between removal length of the terminal ileum and stool frequency per day



Relationship between gastrointestinal transit time and daily stool frequency in patients after Ileal J pouch-anal anastomosis for ulcerative colitis. **Tomita R - *Am J Surg* - 01-JAN-2004; 187(1): 76-82**

Fluid Replacement

- The electrolyte content of the effluent is replaced volume for volume with normal saline to approximate the sodium and chloride content of small intestinal fluid
- Urine output is carefully measured and fluids are adminstered to maintain 0.5ml/kg/hr
- Serum electrolytes are checked daily and repleted as needed

Fluid Replacement

- Oral rehydration solutions were developed following the realization that in many small bowel diarrheal illnesses the intestine can still absorb water if glucose and salt are present to assist in the transport of water from the intestinal lumen.

- The oral rehydration solution recommended by the World Health Organization consists of 3.5 g sodium chloride, 2.5 g sodium bicarbonate, 1.5 g KCl, 20 g of the mixture in 1L of clean drinking water.

Conclusion

- Patients should be advised to use salt liberally and to increase their fluid intake, especially at times of stress, particularly in extremely hot weather and after vigorous exercise.

- A balanced salt solution (e.g., Gatorade® or Powerade®) is a great source of balanced electrolytes.