WATER AND ELECTROLYTE DISTRIBUTION

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In a typical adult male, the total body water (TBW) is approximately 60% of the body weight (somewhat more for infants and somewhat less for women). Of a TBW of 40 litres, 25l is located inside cells (the intracellular fluid or ICF) while the remainder, some 15 litres, is in the extracellular fluid (ECF) compartment Of the ECF, the plasma is itself a small fraction (some 3 litres) while the) remainder is interstitial fluid within the tissues but outside the cells

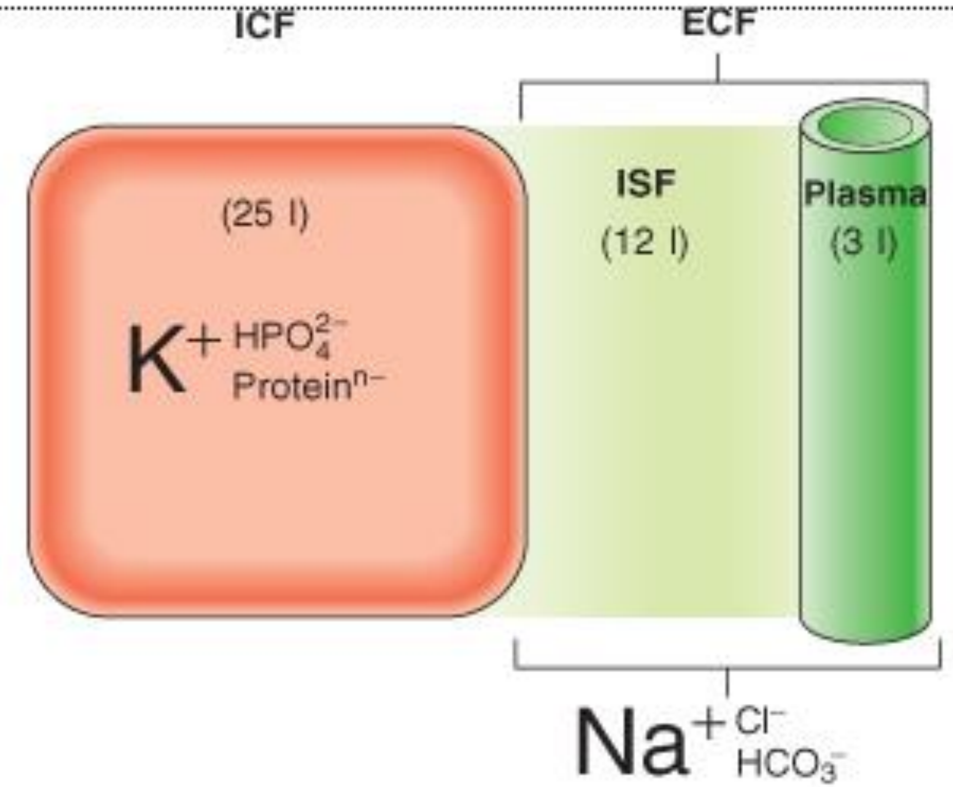
The solute or particle concentration of a fluid is known as its *osmolality* and is expressed as milliosmoles per kilogram of water (mosmol/kg).

The extracellular and intracellular solutes or osmoles are markedly different due to disparities in permeability .and the presence of transporters and active pumps.

some of the major differences in composition between the main body fluid compartments. The dominant cation in the ICF is potassium, while the dominant cation in the ECF is sodium.

Phosphates and negatively charged proteins constitute the major intracellular anions, while chloride and, to a lesser extent, bicarbonate dominate the ECF anions. An important difference between the plasma and interstitial compartments of the ECF is that only plasma contains significant .concentrations of protein

40L


ICF
ECF
ISF
(12 l)
Plasma
(3 l)
(25 l)
K^+ HPO_4^{2-}
$Protein^{n-}$
Na^+ Cl^-
HCO_3^-


2/3 of body weight =
TOTAL BODY WATER
2/3 = Intracellular fluid
1/3 =
Intracellular fluid
3/4 =
Interstitial
fluid
1/4 =
Plasma

- The major force maintaining the difference in cation concentration between the ICF and ECF is the activity of the sodium-potassium pump (Na,K-activated ATPase) integral to all cell membranes. Maintenance of the cation gradients across cell membranes is essential for many cell processes, including the excitability of conducting tissues such as nerve and muscle.
- The difference in protein content between the plasma and the interstitial fluid compartment is maintained by the protein permeability barrier at the capillary wall. This protein concentration gradient contributes to the balance of forces across the capillary wall favouring fluid retention within the capillaries (the colloid osmotic, or oncotic, pressure of the plasma), thus maintaining an adequate .circulating plasma volume
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- The concentrations of fluid and electrolytes in the cells and fluid compartments of the body are remarkably constant despite a widely varying intake. This equilibrium is maintained by fluid and solute shifts across the cells of the body through well-defined mechanisms and by the capacity of the kidney to regulate the urinary excretion of water, electrolytes, and solutes in response to the needs of the body
- the solute content of body water is maintained between 280 and 290 mOsm/kg of water

Water Intake •

The primary stimulus for water ingestion is •

-thirst,mediated either by an increase in effective osmolality •

or a decreasein ECF volume or blood pressure. •

- *Osmoreceptors*, located in the anterolateral hypothalamus, • are stimulated by a rise in tonicity.

Ineffective osmoles, such as urea and glucose, do •
not play a role in stimulating thirst. The average osmotic •
threshold for thirst is approximately 295 mosmol/kg and •
varies among individuals. Under normal circumstances, •
daily water intake exceeds physiologic requirements •

Water Excretion •

In contrast to the ingestion of water, its excretion is tightly •
regulated by physiologic factors. The principal determinant •
of renal water excretion is *arginine vasopressin* (AVP; •
formerly antidiuretic hormone), •

DISORDERS OF WATER BALANCE •

Daily water intake can vary over a wide • range, from 500 ml to several litres a day. While a certain amount of water is lost through the stool, sweat and the respiratory tract, the kidneys are chiefly responsible for adjusting water excretion to maintain constancy of body water content and body fluid osmolality (normal range 280-290 .(mosmol/kg

VOLUME EXCESS

- Volume expansion occurs when salt and water intake exceeds renal and extrarenal losses.
- .\ The sodium and water retention may be primary, from an increased ECV(Increased Effective Circulating Volume) or secondary, in response to a decreased ECV. The net result of renal sodium and water retention is an alteration of Starling forces that leads to increased capillary hydrostatic pressure and favors fluid shifts from the intravascular to interstitial space. Most patients with nephrotic syndrome have an increased ECV volume resulting from primary renal sodium retention, whereas in a subgroup of patients with nephrotic syndrome with minimal pathologic change, secondary renal sodium retention is due to a decreased ECV. In advanced liver disease, the ECV is decreased because of arterial underfilling from vasodilation that results in secondary renal sodium retention. However, in early liver disease, the volume excess may result from primary renal sodium retention. Severe hypoalbuminemia associated with liver disease, nephrotic syndrome, or severe malnutrition may overwhelm the local capillary homeostatic mechanisms and may lead to edema formation
- Clinical features

Causes of Volume Excess

- **Primary Renal Sodium Retention (Increased (Effective Circulating Volume**
- Acute renal failure
- Acute glomerulonephritis
- Severe chronic renal failure
- Nephrotic syndrome
- Primary hyperaldosteronism
- Cushing's syndrome
- Liver disease
- **Secondary Renal Sodium Retention (Decreased Effective Circulating Volume)**
- Heart failure
- Liver disease
- Nephrotic syndrome (minimal change disease)
- Pregnancy

- The mainstay in treating volume excess is dietary sodium restriction ,decrease fluid intake
- in combination with diuretics

DIURETICS

1-Carbonic anhydrase inhibitors (acetazolamide) Proximal tubule

2-Loop diuretics (furosemide, bumetanide, ethacrynic acid)Thick ascending limb of loop of Henle

3 Thiazides Distal convoluted tubule

4- Metolazone Distal tubule, proximal tubule

5-Aldosterone antagonists (spironolactone)Cortical collecting duct

6-Primary sodium-channel blockers (triamterene, amiloride)Cortical collecting duct

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volume depletion •

- Mild volume depletion may be associated with orthostatic dizziness and tachycardia. As the intracellular compartment becomes further depleted, recumbent tachycardia becomes evident and urine output diminishes. Patients with severe volume depletion may present with vasoconstriction, hypotension, mental obtundation, cool extremities, and negligible urine output. Many of these clinical features can be explained on the basis of effects of vasoconstrictor hormones, such as catecholamine and angiotensin II, that are released in response to hypovolemia
- Sunken eyes ,wrinkle of skine ,depressed fontenel .,dry mouth

HYPOVOLEMIA •

Etiology •

True volume depletion, or hypovolemia, generally refers •
to a state of combined salt and water loss exceeding •
intake, leading to ECF volume contraction. The loss of •
may be renal or extrarenal •

Causes of Volume Depletion •

- 1-Gastrointestinal losses •
- *Upper* •
- bleeding, nasogastric suction, vomiting : •
- :*Lower* •
- bleeding, diarrhea, enteric or pancreatic fistula, tube drainage •
- 2-Renal losses •
- *Salt and wate :-*diuretics, osmotic diuresis, postobstructive diures •
- acute tubular necrosis (recovery phase), salt-losing nephropathy, adrenal insufficiency, renal tubular acidosis •
- *Water* : diabetes insipidus •
- 3-Skin and respiratory loss: •
- Sweat, burns, insensible losses •
- 4-Sequestration without external fluid loss •
- Intestinal obstruction, peritonitis, pancreatitis, rhabdomyolysis •

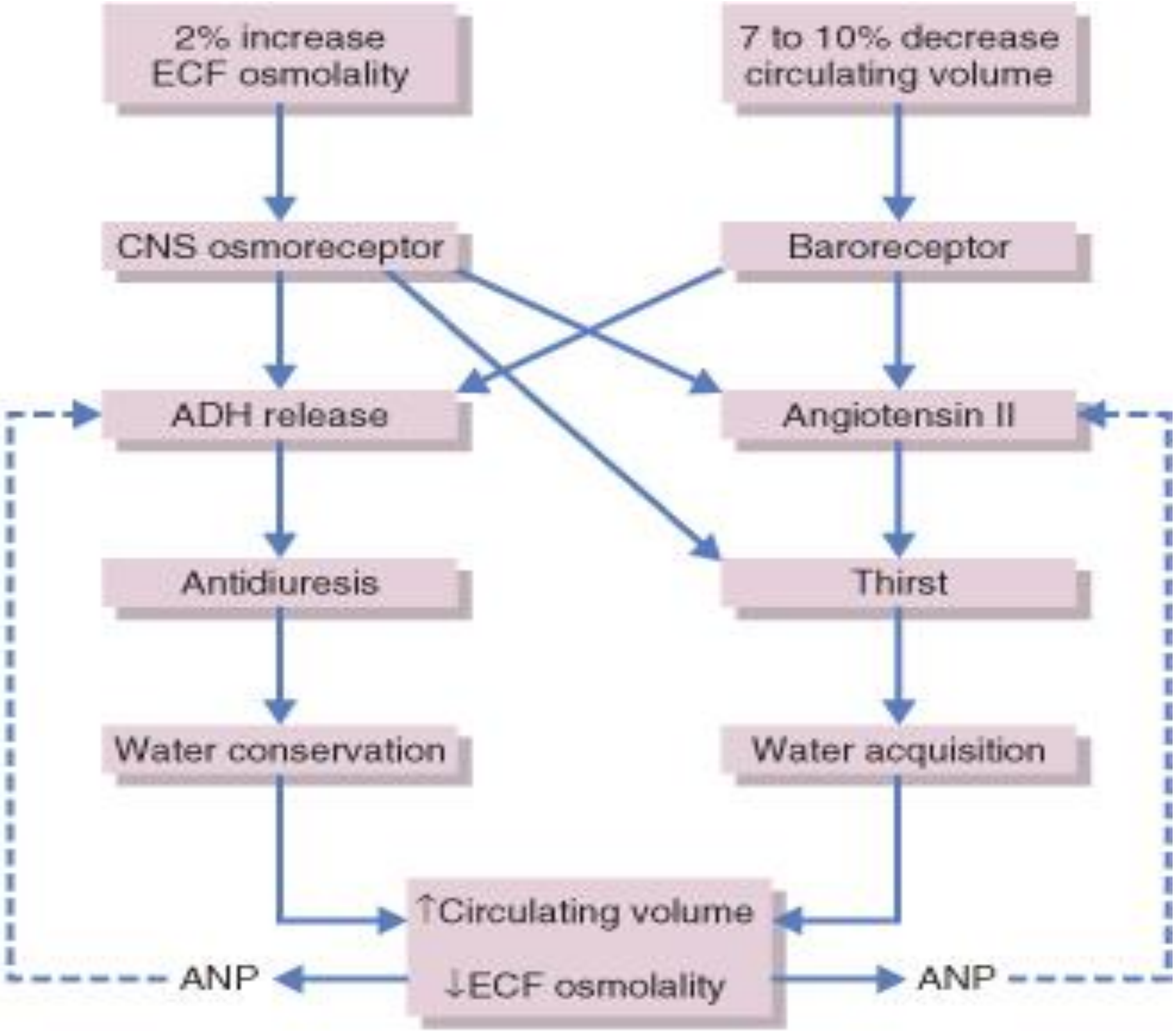
- Treatment
- The absolute quantity and the rate of fluid replacement depend on the severity of volume depletion, which is estimated by the clinical presentation. If fluid repletion is to involve parenteral infusions, one should consider the distribution of the infused fluid. Solutions containing 0.9% sodium chloride and colloid solutions, which are retained in the extracellular space, are the preferred parenteral solutions for the treatment of hypovolemia. In contrast, only one third of infused 5% glucose in water (D
- W) remains in the extracellular compartment.
- Treatment of primary cause

Osmolality Disorders •

Body fluid osmolality, the ratio of solute to water in all fluid compartments, is maintained within an extremely narrow range. Because water moves freely across most cell membranes, changes in the extracellular fluid osmolality cause reciprocal changes in the intracellular volume. The extracellular fluid osmolality can be approximated by calculating the serum osmolality based upon the major solutes in that compartment •

:=29(Na)+glucose/18+BUN/2.8 •

where the glucose and blood urea nitrogen (BUN) concentrations are expressed as milligrams per deciliters, and the serum sodium concentration is .expressed as milliequivalents per liter


2% increase ECF osmolality
7 to 10% decrease circulating volume
CNS osmoreceptor
Baroreceptor
ADH release
Angiotensin II
Antidiuresis
Thirst
Water conservation
Water acquisition
↑Circulating volume
↓ECF osmolality
ANP
ANP