

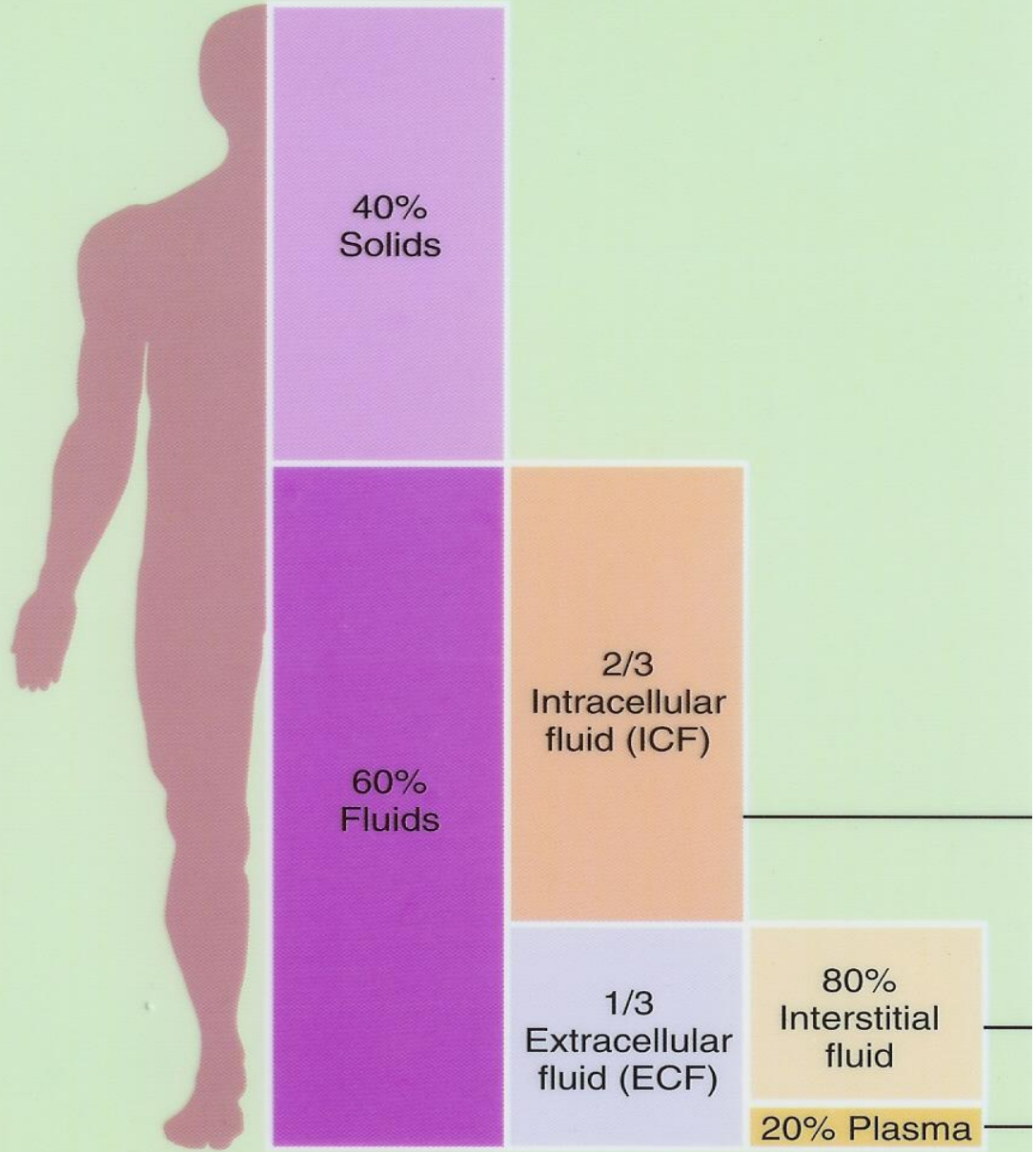
# ***Sodium and Water***

Dr . BOSHRA HASANZAMANI  
[www.mums.ac.ir/rsc-ktc](http://www.mums.ac.ir/rsc-ktc)

Total body weight (female)



Total body weight (male)



- Fluid movement between the intravascular and interstitial spaces :Starling forces, i.e., capillary hydraulic pressure and colloid osmotic pressure

# osmolality

- The solute or particle concentration of a fluid (mosmol/kg)
- ECF osmolality = ICF osmolality

# osmolality

- **effective osmolality** :The major ECF particles are  $\text{Na}^+$  and its accompanying anions  $\text{Cl}^-$  and  $\text{HCO}_3^-$
- ***ineffective osmoles***: do not contribute to water shifts across most membranes ( urea )

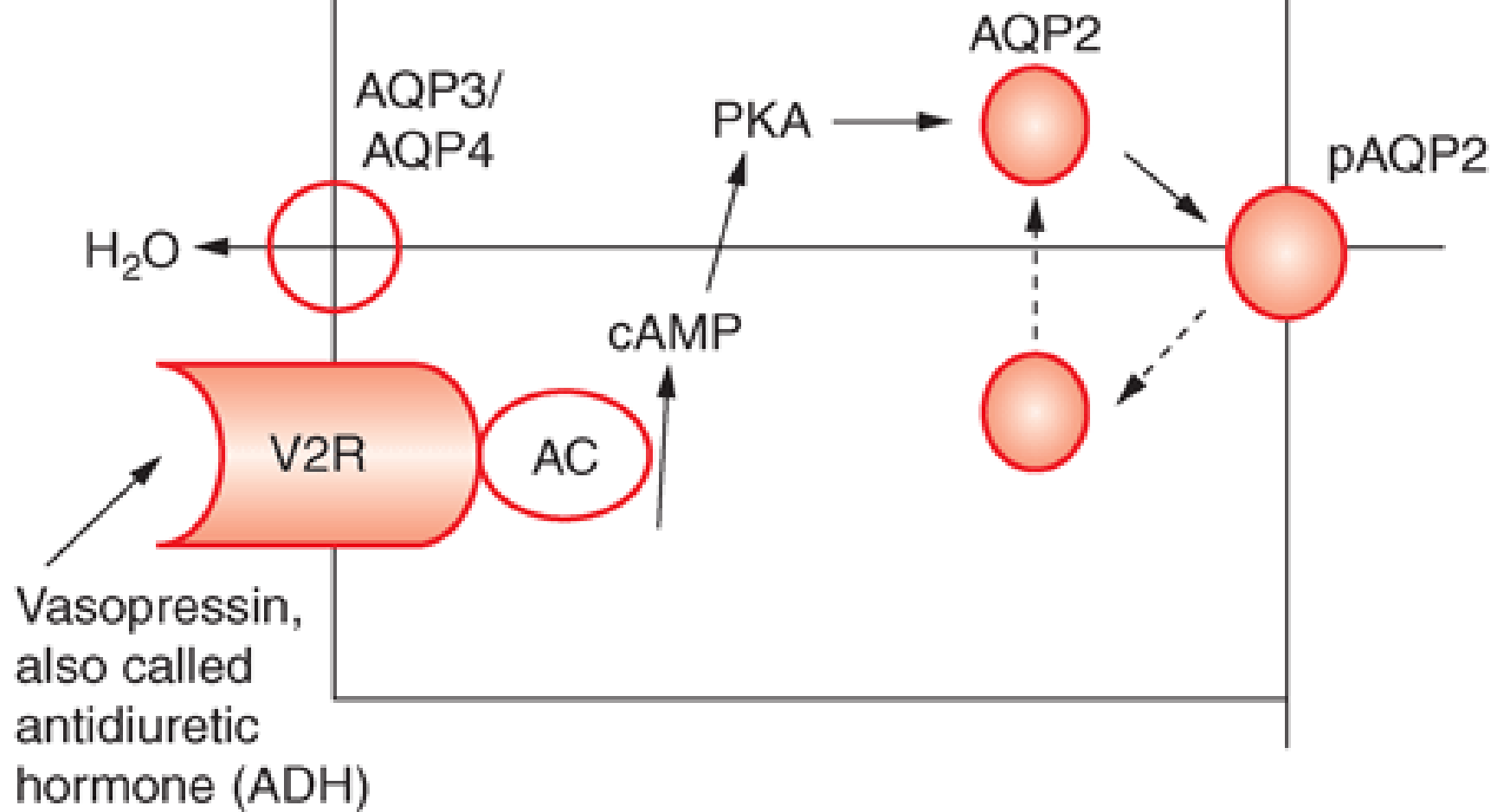
# *Water Balance*

- human body fluid osmolality between **280 and 295 mosmol/kg**:
  - Vasopressin secretion( AVP)
  - water ingestion
  - renal water transport
- AVP secretion is stimulated as systemic osmolality increases above a threshold level of **285 mosmol/kg**

Medullary Interstitium (Vasa Recta or Blood Side)

Collecting duct principal cell

Tubule Lumen (Urine)





# *Hypovolemia*



# *Etiology*

- *Renal* Causes
  - osmotic diuresis
    - endogenous solutes : glucose and urea
    - Exogenous : mannitol
  - Pharmacologic diuretics
  - mineralocorticoid deficiency,
  - tubulointerstitial injury
  - central and nephrogenic diabetes insipidus

- *Extrarenal* Causes :
  - fluid loss from the gastrointestinal tract, skin, and respiratory system
  - "third spacing" : This occurs in sepsis syndrome, burns, pancreatitis, nutritional hypoalbuminemia, and peritonitis
  - hemorrhage

# Symptoms of hypovolemia

- nonspecific
- Include : fatigue, weakness, thirst, and postural dizziness
- severe symptoms and signs include oliguria, cyanosis, abdominal and chest pain, and confusion or obtundation

# signs of hypovolemia

- reliable signs of hypovolemia include :
  - decreased jugular venous pressure (JVP)
  - orthostatic tachycardia (an increase of >15–20 beats per minute upon standing)
  - orthostatic hypotension (a >10–20-mmHg drop in blood pressure on standing)

- severe fluid loss leads to **hypovolemic shock**, with hypotension, tachycardia, peripheral vasoconstriction, and peripheral hypoperfusion; these patients may exhibit peripheral cyanosis, cold extremities, oliguria, and altered mental status

# *Diagnostic Evaluation*

- Routine chemistries :
  - increase in blood urea nitrogen (BUN) and creatinine
  - acid-base disorders
  - nonrenal causes : urine  $\text{Na}^+$  concentration is  $<20 \text{ mM}$  - urine osmolality of  $>450 \text{ mosmol/kg}$
  - increase in plasma  $\text{K}^+$  concentration

# ***Sodium Disorders***



# Hyponatremia

- plasma  $\text{Na}^+$  concentration  $<135 \text{ mM}$
- occurring in up to 22% of hospitalized patients
- the result of :
  - increase in circulating AVP and/or increased renal sensitivity to AVP, combined with any intake of free water
  - low solute intake



- Hyponatremia thus is subdivided diagnostically into three groups, depending on clinical history and volume status:
  1. hypovolemic,
  2. Euvolemic
  3. hypervolemic

# Hypovolemic Hyponatremia

- Hypovolemia causes :
  - neurohumoral activation
  - increasing circulating levels of AVP

# Hypervolemic Hyponatremia

- increase in total body  $\text{Na}^+\text{-Cl}^-$  that is accompanied by a proportionately *greater* increase in total body water,
- acute or chronic renal failure
  - increase in urine  $\text{Na}^+$  concentration
- edematous disorders [congestive heart failure (CHF), cirrhosis, and nephrotic syndrome]
  - Urine  $\text{Na}^+$  concentration is typically very low, i.e.,  $<10 \text{ mM}$
- The degree of hyponatremia is an important prognostic indicator in hypervolemic hyponatremia

# Euvolemic Hyponatremia

- moderate to severe hypothyroidism
- secondary adrenal insufficiency due to pituitary disease
- syndrome of inappropriate antidiuresis is the most common cause of euvolemic hyponatremia

# Clinical Features of Hyponatremia

- Acute hyponatremic **encephalopathy**
- Early symptoms can include nausea, headache, and vomiting
- seizure activity, brainstem herniation, coma, and death
- the associated hypoxemia may amplify the neurologic injury
- Women, particularly before menopause, are much more likely to develop encephalopathy and severe neurologic sequelae

Assessment of volume status

Hypovolemia

- Total body water ↓
- Total body sodium ↓↓

$U_{Na} > 20$

$U_{Na} < 20$

- Renal losses
- Diuretic excess
- Mineral corticoid deficiency
- Salt-losing deficiency
- Bicarbonaturia with renal tubal acidosis and metabolic alkalosis
- Ketonuria
- Osmotic diuresis
- Cerebral salt wasting syndrome

- Extrarenal losses
- Vomiting
- Diarrhea
- Third spacing of fluids
- Burns
- Pancreatitis
- Trauma

Euvolemia (no edema)

- Total body water ↑
- Total body sodium ↔

$U_{Na} > 20$

- Glucocorticoid deficiency
- Hypothyroidism
- Stress
- Drugs
- Syndrome of inappropriate antidiuretic hormone secretion

Hypervolemia

- Total body water ↑↑
- Total body sodium ↑

$U_{Na} > 20$

- Acute or chronic renal failure

$U_{Na} < 20$

- Nephrotic syndrome
- Cirrhosis
- Cardiac failure

# Diagnostic Evaluation of Hyponatremia

- Laboratory investigation :
  - serum osmolality
  - patients with hyponatremia have an effective osmolality  $<275$  mosmol/kg
  - BUN and creatinine
  - hyperkalemia may suggest adrenal insufficiency or hypoaldosteronism
  - plasma  $\text{Na}^+$  concentration falls by 1.6 to 2.4 mM for every 100-mg/dL increase in glucose
  - serum uric acid
  - thyroid, adrenal, and pituitary function should also be tested
  - Urine electrolytes and osmolality are crucial tests

# ***Hypernatremia***

A thick, solid blue horizontal bar with rounded ends, positioned in the lower right quadrant of the slide.



- plasma  $\text{Na}^+$  concentration to  $>145 \text{ mM}$
- less common than hyponatremia
- associated with mortality rates as high as 40–60%

# Etiology

- central defect in hypothalamic osmoreceptor function
  - decreased thirst and reduced AVP secretion
- loss of water via both renal and nonrenal routes
  - **nonrenal** :
- Insensible losses of water
- Diarrhea is the most common gastrointestinal cause of hypernatremia
- osmotic diarrhea and viral gastroenteritis typically generate stools with  $\text{Na}^+$  and  $\text{K}^+ < 100 \text{ mM}$ , thus leading to water loss and hypernatremia
- secretory diarrhea typically results in isotonic stool and thus hypovolemia with or without hypovolemic hyponatremia

- Renal :
- osmotic diuresis :
  - hyperglycemia, excess urea, postobstructive diuresis, and mannitol
- DI:
  - NDI
  - CDI

# Clinical Features

- the symptoms of hypernatremia are predominantly neurologic
  - **Altered mental status** is the most common manifestation, ranging from mild confusion and lethargy to deep coma
  - The sudden shrinkage of brain cells in acute hypernatremia may lead to parenchymal or **subarachnoid hemorrhages** and/or **subdural hematomas**

# Diagnostic Approach

- history :
  - presence or absence of thirst, polyuria, and/or an extrarenal source for water loss, such as diarrhea
- physical examination :
  - neurologic exam
  - assessment of the ECFV
  - Accurate documentation of daily fluid intake and daily urine output

# Laboratory investigation

- measurement of serum and urine **osmolality** in addition to urine electrolytes
- extrarenal source of water loss :
  - excretion of low volumes (<500 mL/d) of maximally concentrated urine, i.e., urine with osmolality >800 mosmol/kg
- osmotic diuresis :
  - excessive excretion of Na<sup>+</sup>-Cl<sup>-</sup>, glucose, and/or urea, solute excretion will be >750–1000 mosmol/d (>15 mosmol/kg body water per day)
  - polyuric
- More commonly, patients with hypernatremia and polyuria will have a predominant water diuresis, with excessive excretion of hypotonic, dilute urine

