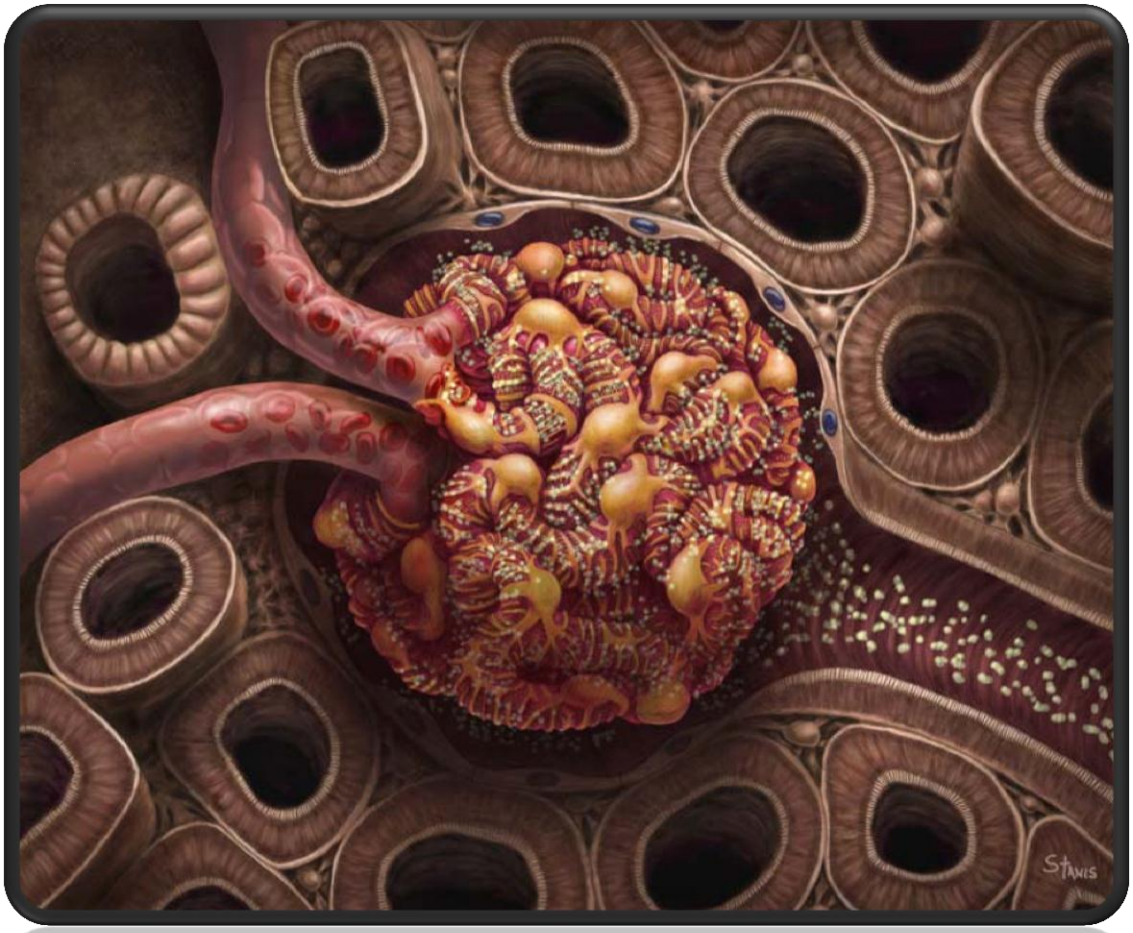
Physiology Team 431



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Renal Regulation of ECV and osmolality

6th lecture

Objectives

1- **Identify and describe the role of the Sensors and Effectors in the renal regulation of body fluid volume**
2- **Identify and describe the role of the Sensors and Effectors in the renal regulation of body fluid osmolality**
3- **Role of the kidney in volume regulation**
4- **Role of the kidney in ECF osmolality**

Renal regulation of Extra Cellular Volume :

Is a reflex mechanism in which variables reflecting total body sodium and ECV are monitor by appropriate sensor (receptors)

Regulation of ECF volume = Regulation of body Na^+ = Regulation BP

Thus, regulation of Na^+ also dependent upon **BARORECEPTORS.**

Renal Regulation of ECV :

- **Changes in ECV, Na and Pressure**

Sensor

- Carotid sinus — contains numerous baroreceptors, which function as a "sampling area" for many homeostatic mechanisms for maintaining blood pressure.
- Volume receptors (large vein, atria, intrarenalartery)
  - If there is any change of the body volume, it will be detected by these receptors.

Effectors

- Renin \ angiotensin, aldesterone
- Renal sympathetic nerve
- ANF
- ADH

Affecting

- Urinary Na excretion

ECF volume Receptors :

1.Central vascular sensors

- **Low pressure receptors (the most important)**
  - ✓ Cardiac atria
  - ✓ Pulmonary vasculature
- **High pressure receptors (less important)**
  - ✓ Carotid sinus
  - ✓ Aortic arch
  - ✓ Juxtaglomerularapparatus (renal afferent arteriole)

" Low pressure" receptor ➔ located in the low pressure side of the circulation.

2.Sensors in the CNS (less important)

3.Sensors in the liver (less important)

Effectors :

1. Renin-angiotensinAldsterone

- Reninis released into plasma when plasma Na ↓ (in macula densa)
- Renin ➔ angiotensinogen ➔ AngiotensinI
- AngiotensinI ➔ ACE ➔ angiotensinII
- angiotensinII acts on adrenal cortex ➔ aldosterone secretion ➔ ↑Na reabsorption in distal & collecting duct of nephron.

2. Renal Sympathetic

- ↓ ECV ➔ ↑ renal sympathetic activity ➔ **stimulate Na absorption by direct tubular effect mediated through α-receptors on renal tubules (mainly PCT)** to correct for low ECV .

 # another function of RENAL SYMPATHETIC :

Sympathetic nerve stimulation causes renal vasoconstriction and a consequent decrease in renal blood flow. Renal sympathetic nerves are activated under stressful conditions, including cold temperatures, deep anesthesia, fearful situations, hemorrhage, pain, and strenuous exercise. In these conditions, renal vasoconstriction may be viewed as an emergency mechanism that increases total peripheral resistance, raises arterial blood pressure, and allows more of the cardiac output to perfuse other vital organs, such as the brain and heart, which are more important for short-term survival.

3. ATRIAL NATRIURETIC PEPTIDE (ANP)

- ↑ ECV ➔ Stretch of Atria ➔ release ANP ➞ **inhibit aldosterone release** ➔ ↓ sodium reabsorption by collecting duct .

- ↑ sodium excretion and water ➔ correcting for the increase in ECV

(Increases blood flow through the vasa recta will wash the solutes (NaCl and urea) out of the medullary interstitium. The lower osmolarity of the medullary interstitum leads to less reabsorption of tubular fluid and increased excretion.)

- ANP can also **inhibit Renin secretion** .

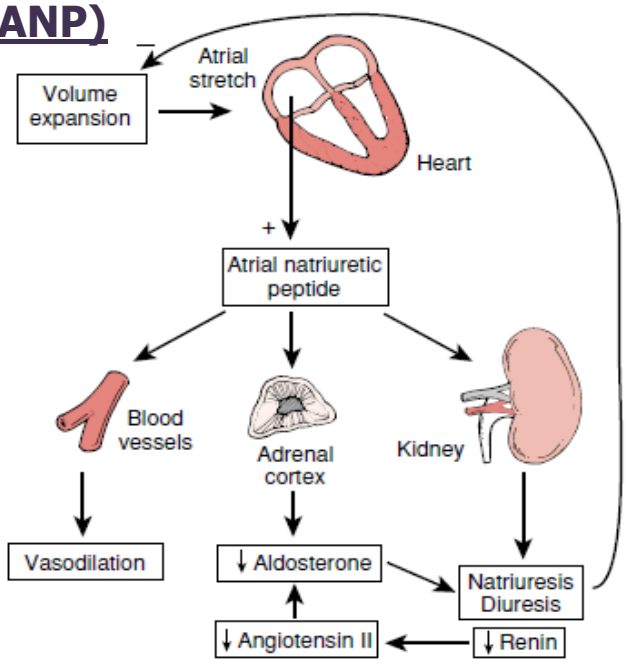


FIGURE 24.10 **Atrial natriuretic peptide and its actions.** ANP release from the cardiac atria is stimulated by blood volume expansion, which stretches the atria. ANP produces effects that bring blood volume back toward normal, such as increased Na^+ excretion.

When ANP is released because of volume expansion from the atria, it will influence on three places:

1-Kidney →inhibits renin secretion → ↓Angiotensin II → ↓Aldestrone → ↓Na reabsorption.

2-Adrenal cortex → ↓Aldosterone →↓Na reabsorption.

3-Blood vessels →Vasodilation →↑GFR →↓ Na reabsorption.

*So, ↑ Na excretion and water, then they all are correcting for the increase in ECV.

In which position diuresis increased, lying down or standing position?

Lying down position ➔ increase venous return ➔ Stretch the atrium ➔ stimulate release of ANP ➔ Inhibition of aldosterone ➔ increase diuresis.

4. Antidiuretichormone ADH

- Increase of plasma osmolality ➔ osmoreceptor ➔ trigger the release of ADH.
- ADH ➔ ↑permeability of collecting duct to H2O ➔ ↑H2O reabsorption ➔ correction of hyperosmolalityof blood.

ADH release stimulated by :

- ↑ Osmolarity
- ↓ Blood volume
- ↓ Blood pressure
- Drugs: Morphine; Nicotine; cyclophosphamide.

Renal Regulation of ECF osmolality :

Is a reflex mechanism in which a changing **plasma osmolalityis** monitor by appropriate sensor **(OSMORECEPTORS)** hypothalamus osmoreceptor.

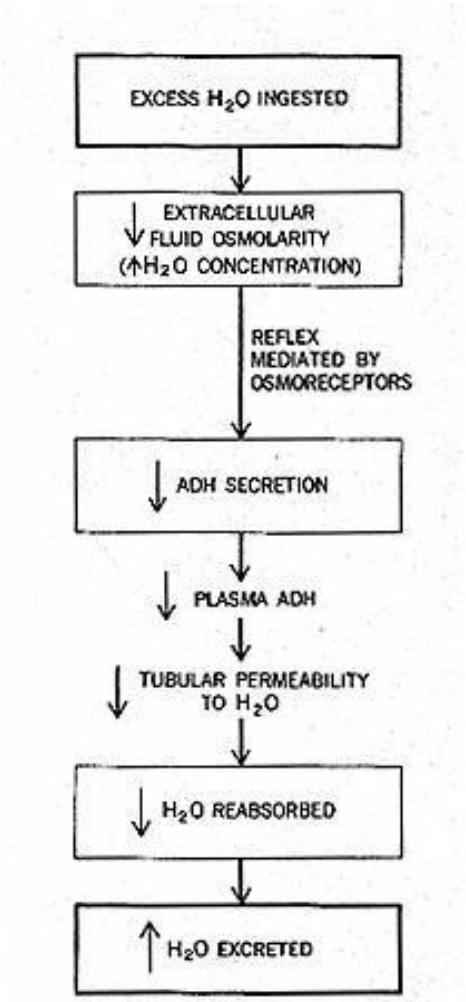
Sensor
- Hypothalamic osmoreceptors :

Effectors
- ADH
- Thirst

Affecting
- Urine osmolaity
- Water intake

Effectors

1. Osmoreceptor ADH Feedback System :



2.Thirst :

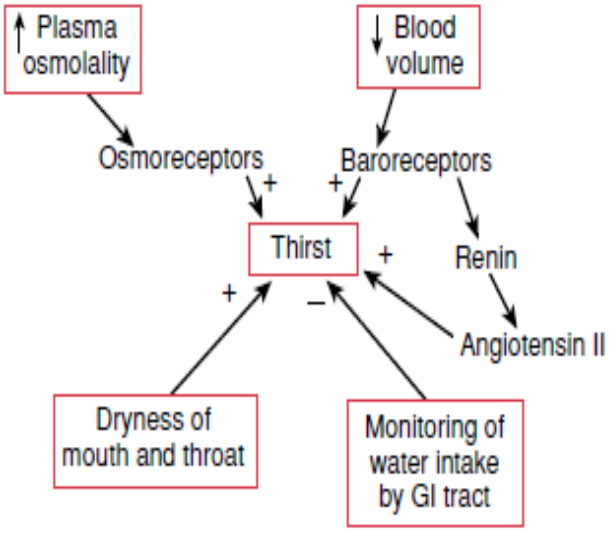


FIGURE 24.7 **Factors affecting the thirst sensation.** A plus sign indicates stimulation of thirst, the minus sign indicates an inhibitory influence.

Thirst sensation stimulated by:

1.↑ Osmolarity

2.↓ Blood volume

3.↓ Blood pressure

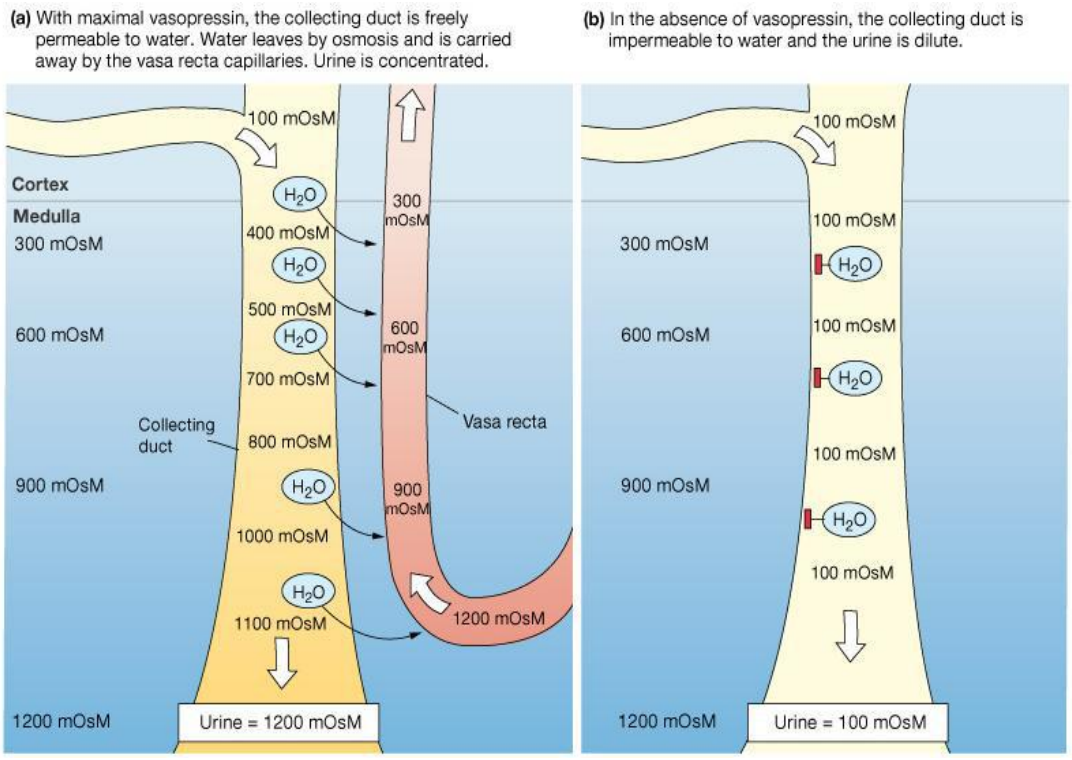
4.↑ Angiotensin

Feeling thirsty lead to consume more water – correcting the hyperosmolality

(Angiotensin II increases thirst sensation through the subfornical organ of the brain, decreases the response of the baroreceptor reflex, and increases the desire for salt.)

5. Dryness of mouth

	Low water intake	High water in take
Plasma osmolality	Increase	Drop
ADH	Stimulate ADH secretion	Inhibit ADH secretion
Collecting duct	Permeable to water	impermeable to water
Urine volume	Small volume (concentrated)	Large volume (diluted)
	* Diluting plasma and a drop in osmolality back to normal. * Accompanied by thirst sensation.	* increase plasma osmolality back to normal.



{Summary}

- One of the main functions of kidney is regulating the ECF volume and osmolarity.
- Two primary systems are especially involved in regulating the volume and osmolarity of extracellular fluid: (1) The osmoreceptor-ADH system and (2) The thirst mechanism.
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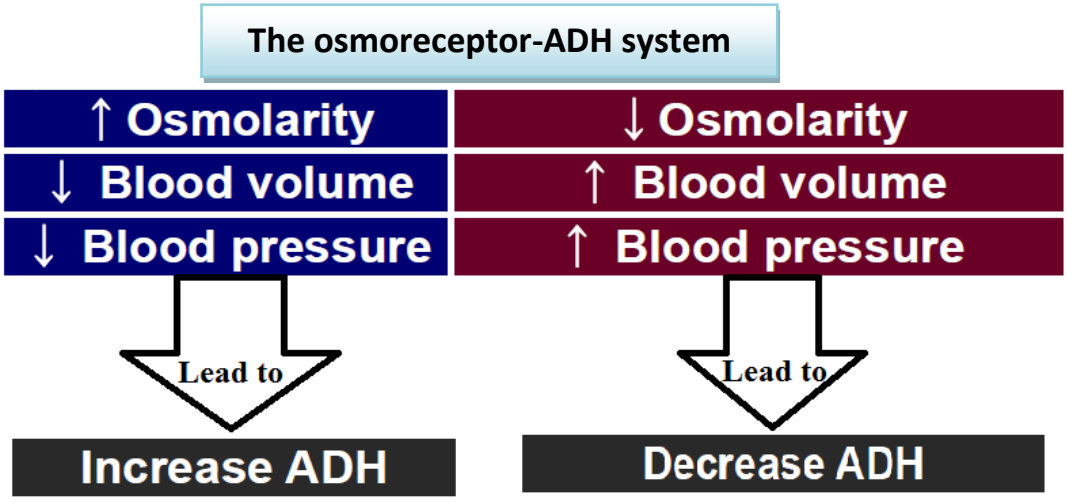

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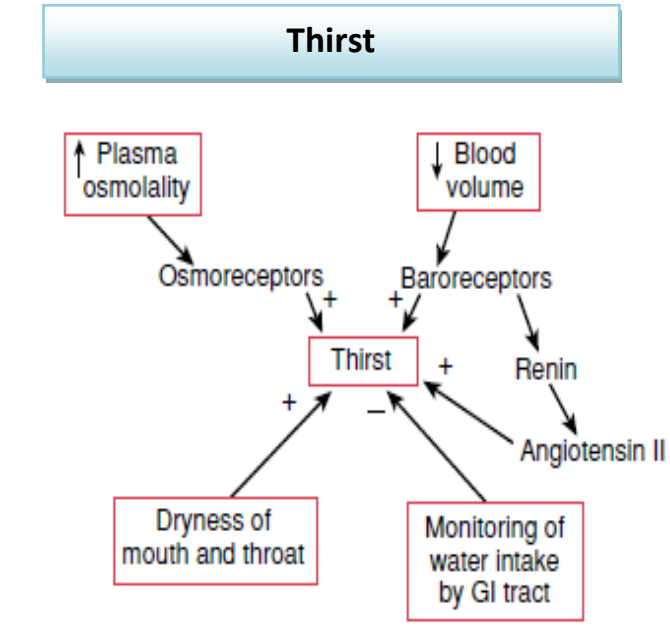

FIGURE 24.7 Factors affecting the thirst sensation. A plus sign indicates stimulation of thirst, the minus sign indicates an inhibitory influence.

- **Thirst centre stimulated by:**

  1) Increase plasma osmolality →Osmoreceptors → + thirst

  2) Decrease blood volume → Baroreceptors → + thirst

  3) Distension of GIT will inhibit the thirst centre

  4) When the mouth and throat are dry, the signals carried by glossopharyngeal and vagus nerves to the thirst centre.

Questions

1- The most important receptor that detect any changes in the ECF volume :

A. Hypothalamic osmoreceptor
B. Low pressure receptor
C. Liver sensors

2- ADH release stimulated by :

A. Increase in blood volume
B. Increase in blood pressure
C. Increase in osmolarity

3- Which of the following sentences is correct :

A. Renal sympathetic activity stimulates Na excretion in response to decrease in ECV.
B. Renal sympathetic activity corrects low ECV by increase Na reabsorption through α-receptor.
C. Renal sympathetic activity released in response to increase in ECV and it inhibits aldosterone and renin secretion.

4- Stimulation of the osmoreceptors in the hypothalamus would be expected to cause all of the following to increase except :

A. ADH release from the pituitary
B. Water reabsorption from the renal collecting duct
C. Rate of urine formation
D. Osmolality of urine

5- Which of the following is the stimulus for increased secretion of atrial natriuretic peptide (ANP) :

A. increase blood plasma osmolality above normal
B. increase systemic arterial pressure
C. increase venous blood volume and atrial pressure
D. increase cardiac contractility (force of contraction)

Answers :

1- B
2- C
3- B
4- C
5- C