REGULATION OF EXTRACELLULAR FLUID VOLUME AND OSMOLALITY

Blood Osmolality (mOsm/L) equals:

$2[Na^+]$ (mEq/L) + 0.055[Glucose] (mg/dL) + 0.36[BUN] (mg/dL)

Chapter 28
pages 348 – 364

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OBJECTIVES

At the end of this lecture you should be able to:

- Identify and describe the role of the Sensors and Effectors in the renal regulation of body fluid volume & osmolality
- Describe the role of the kidney in regulation of body fluid volume & osmolality
- Understand the role of ADH in the reabsorption of water and urea
- Identify the site and describe the influence of aldosterone on reabsorption of Na^+ in the late distal tubules.

Renal regulation of ECF Volume & Osmolality

Is a reflex mechanism in which variables reflecting **total body sodium** and **ECV** are monitored by appropriate sensors

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

Thus, regulation of Na^+ is also dependent upon baroreceptors.

Renal Regulation of ECV

- **Sensor**
  - Carotid sinus
  - Volume receptors (large vein, atria, intrarenal artery)
- **Effectors**
  - Rennin/angiotensin, aldosterone
  - Renal sympathetic nerve
  - ANF
  - ADH
- **Affecting**
  - Urinary Na excretion

Renal regulation of blood osmolality

- **Sensors**
  - Hypothalamic osmoreceptors
- **Effectors**
  - ADH
  - thirst
- **Affecting**
  - Urine osmolaity
  - Water intake

FACTORS AFFECTING ADH

Increase ADH	Decrease ADH
↑ Osmolarity	↓ Osmolarity
↓ Blood volume	↑ Blood volume
↓ Blood pressure	↑ Blood pressure

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

High Osmolality

Low ECF Volume

decreases 15 to 25 percent or more

Osmoreceptors

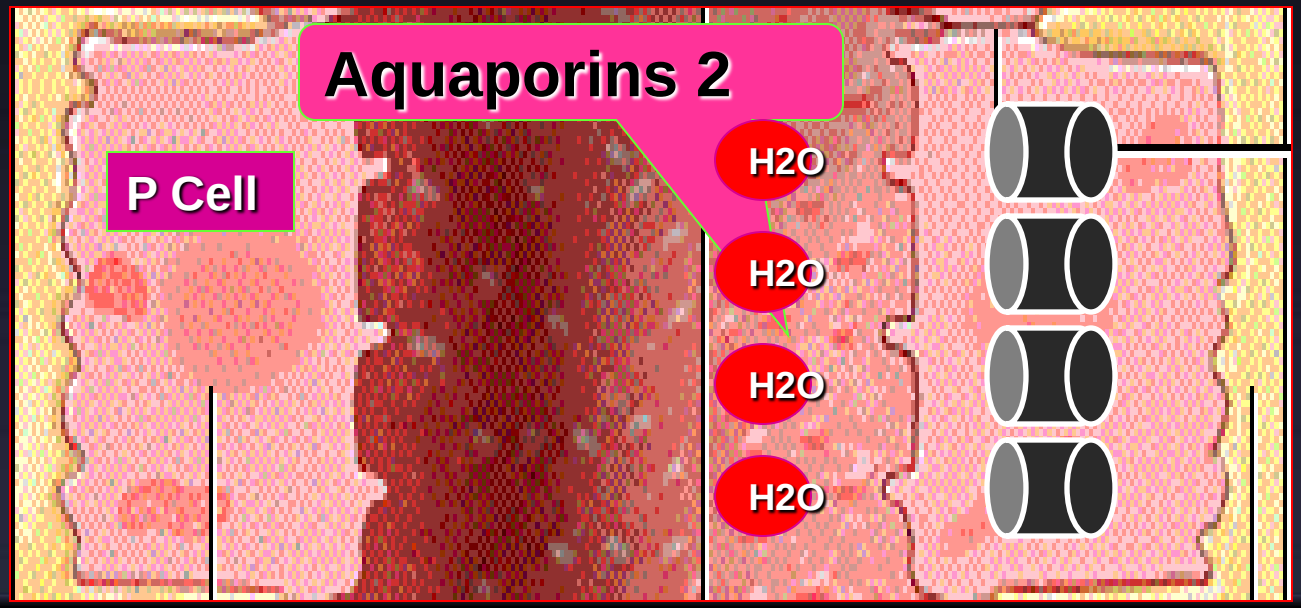
Lat Hypothalamus

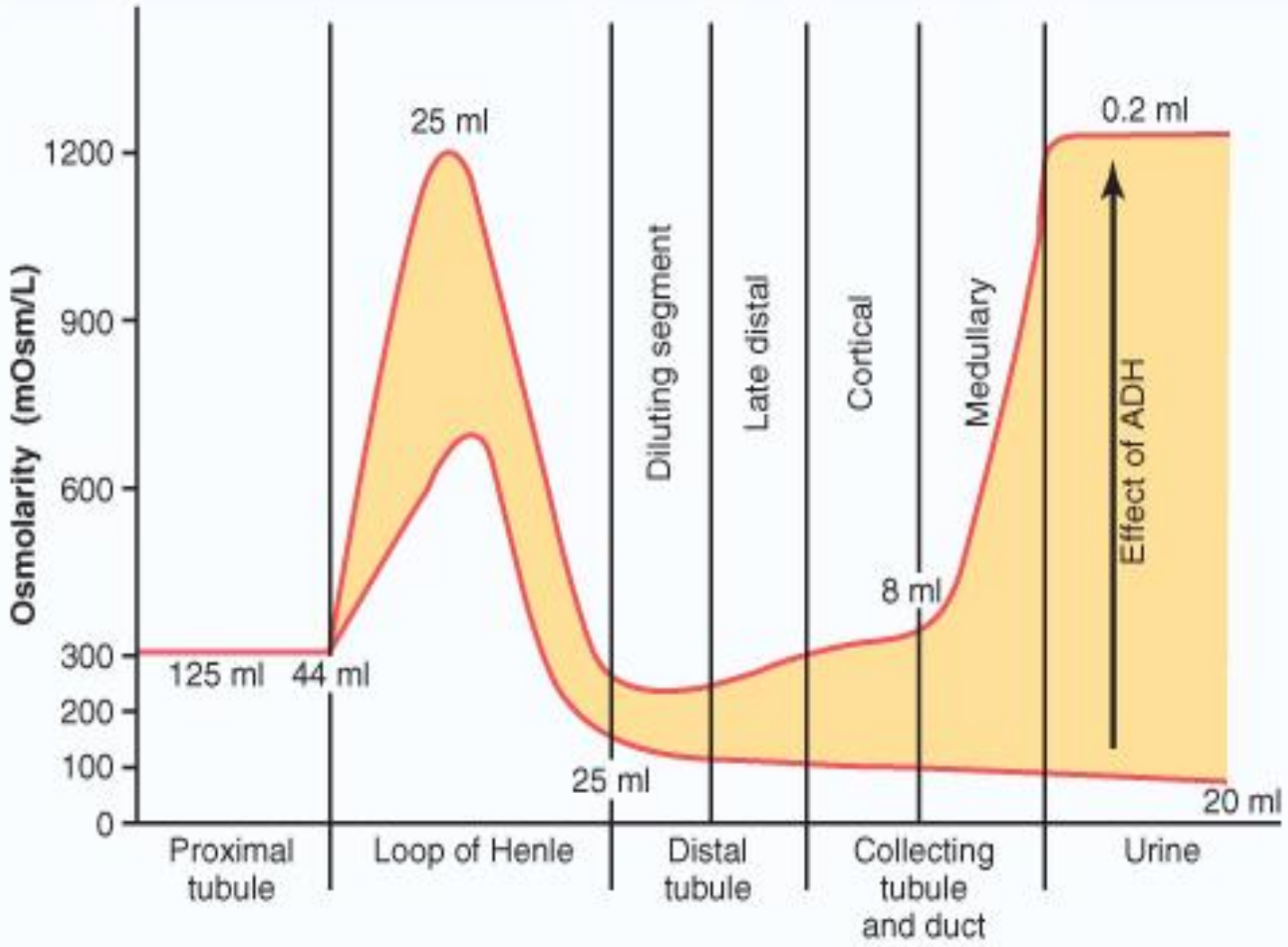
(Stimulate Thirst)

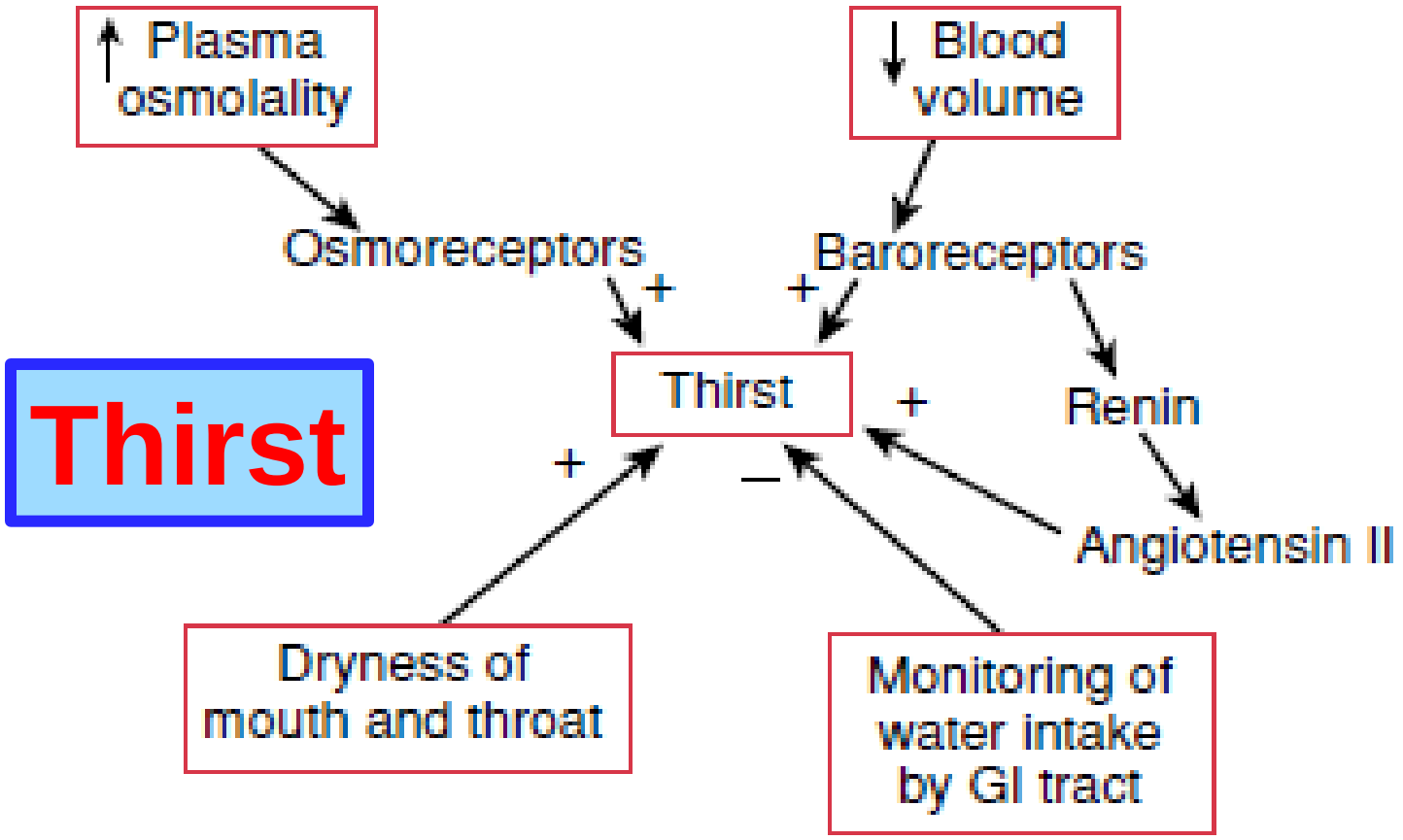
Low Pressure Receptors

Atria Aortic Carotid Pulmonary

↑ADH



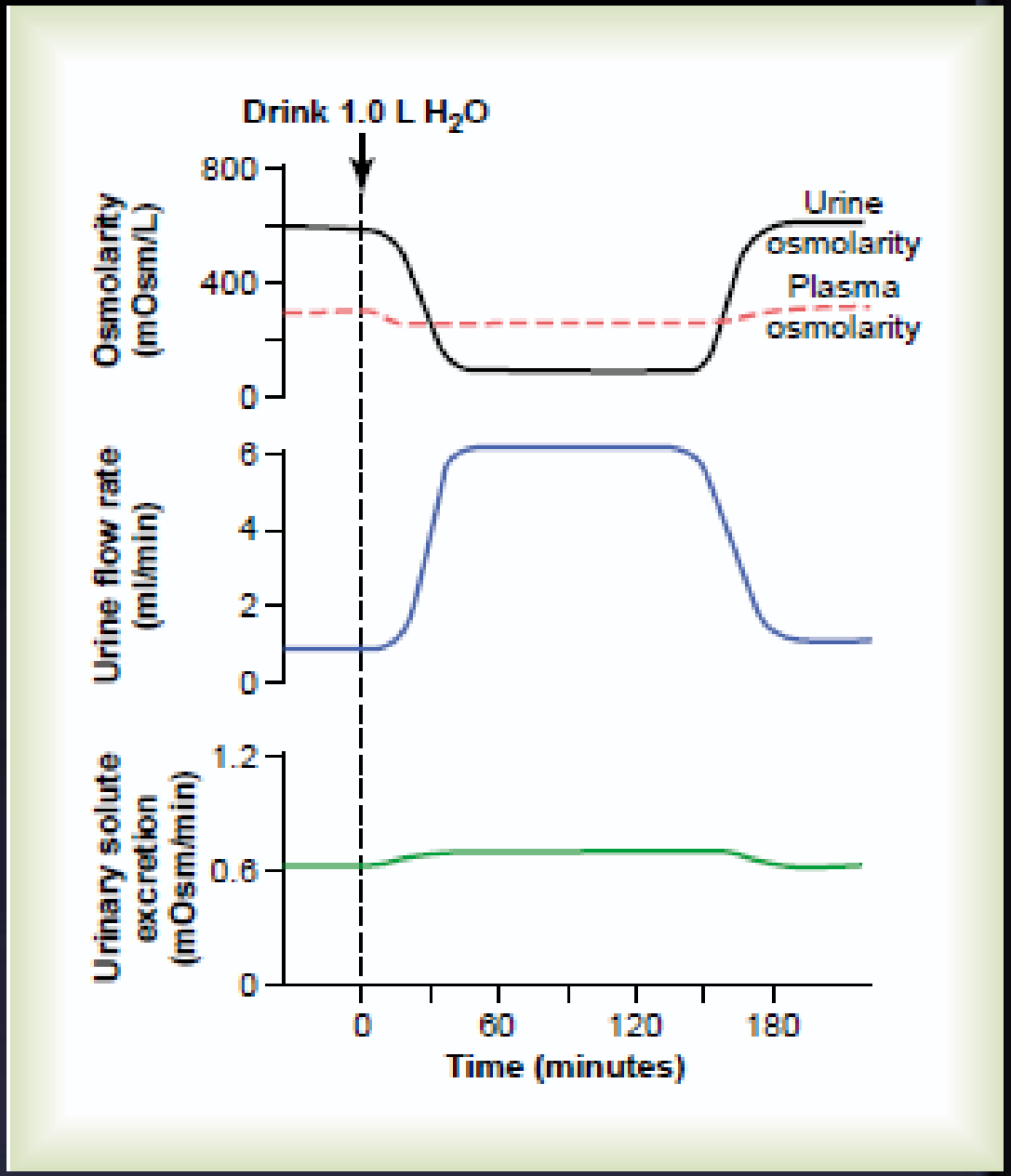

Osmolarity (mOsm/L)
1200
900
600
300
200
100
0
25 ml
0.2 ml
125 ml
44 ml
8 ml
25 ml
20 ml
Diluting segment
Late distal
Cortical
Medullary
Effect of ADH
Proximal tubule
Loop of Henle
Distal tubule
Collecting tubule and duct
Urine



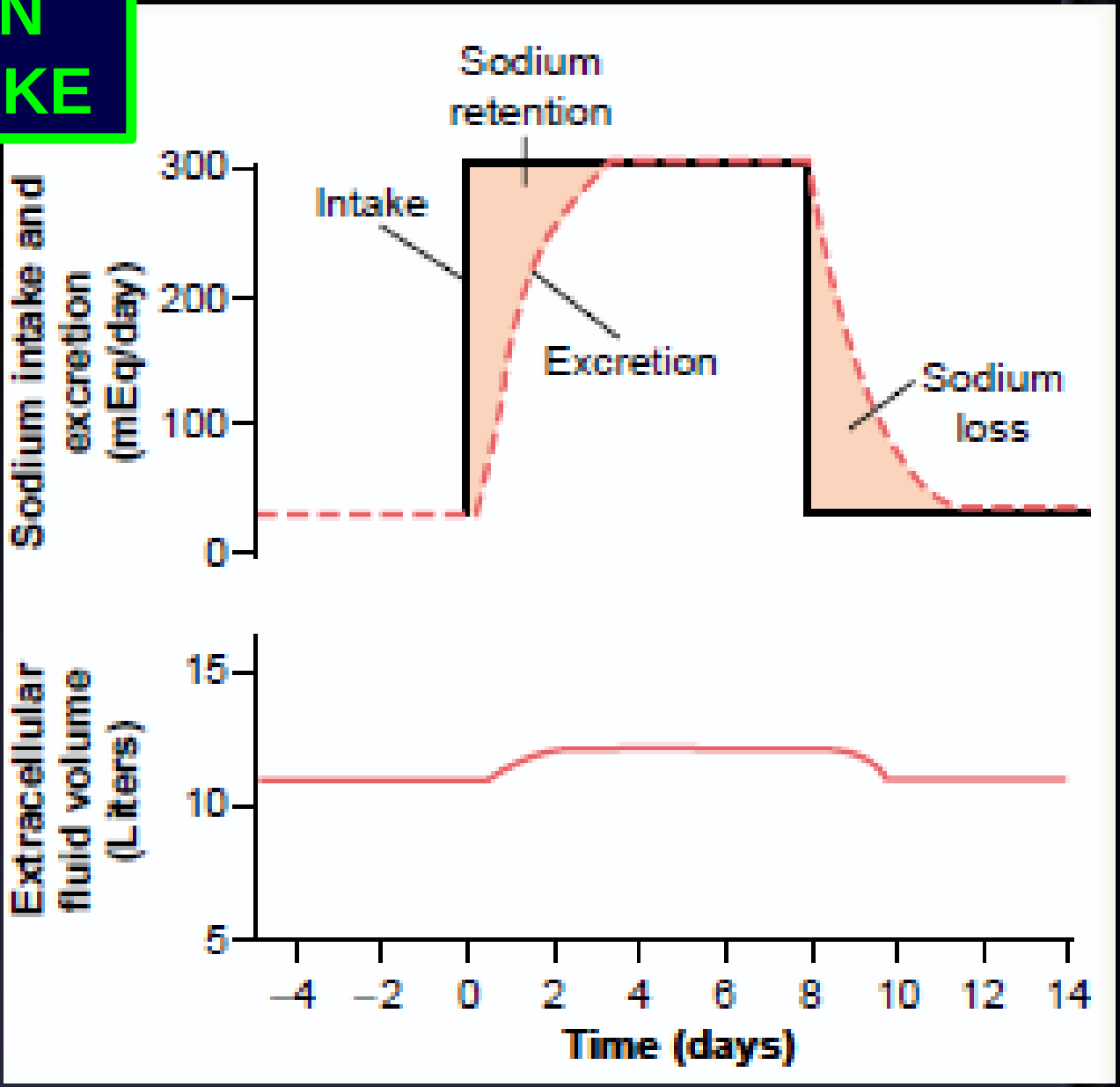
Thirst

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

INCREASE IN WATER INTAKE

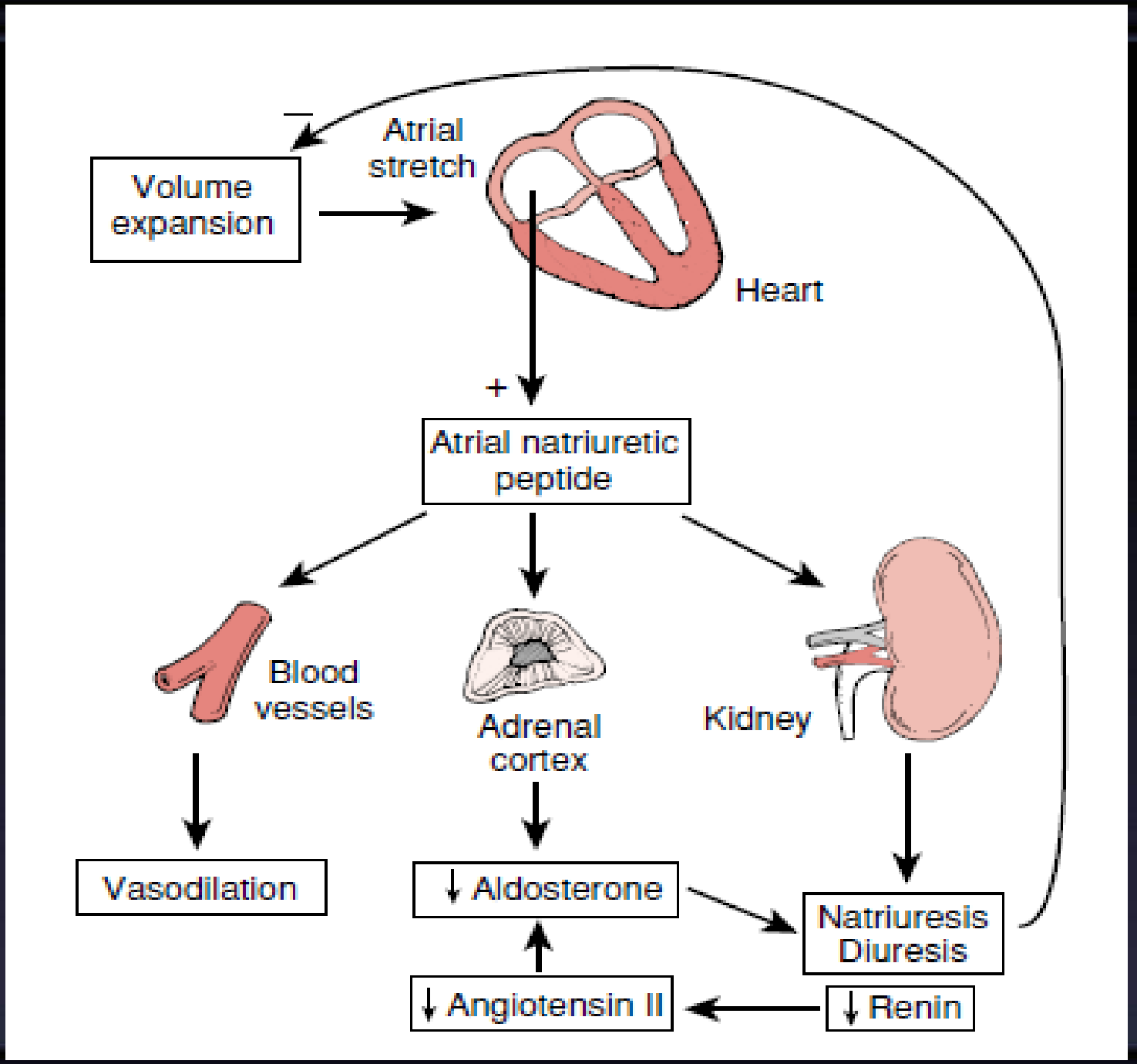


INCREASE IN SODIUM INTAKE



ATRIAL NATRIURETIC PEPTIDE (ANP)

- INCREASE GLOMERULAR FILTRATION
- INHIBIT Na^+ REABSORPTION.
- INCREASE IN CAPILLARY PERMEABILITY LEADING TO EXTRAVASATION OF FLUID AND A DECLINE IN BLOOD PRESSURE.
- RELAX VASCULAR SMOOTH MUSCLE IN ARTERIOLES AND VENULES
- INHIBIT RENIN SECRETION & ALDOSTERONE


Volume expansion
Atrial stretch
Heart
+
Atrial natriuretic peptide
Blood vessels
Adrenal cortex
Kidney
Vasodilation
↓ Aldosterone
Natriuresis Diuresis
↓ Angiotensin II
↓ Renin

ALDOSTERONE EFFECTS

Renal tubules

Aldosterone acts on collecting duct principal cells

(1)increase the Na permeability of the luminal plasma membrane
(2)increase the number and activity of basolateral plasma membrane Na/K-ATPase pumps
(3)increase the luminal plasma membrane K permeability,
(4)increase cell metabolism.
All of these changes result in increased K secretion.

SODIUM HANDLING

SITE	APICAL TRANSPORTER	FUNCTION
Proximal Tubule	•Na/Gluc CT •Na/Pi CT •Na/Amino Acid •Na/Lactate •Na/H Exchanger •Cl/Base Exchanger	•Na & Gluc Uptake •Na & Pi Uptake •Na & AA Uptake •Na & Lactate Uptake •Na Uptake and H Extrusion •Cl Uptake
Thick Ascending Limb	• Na, 2 Cl,, K CT •Na/H Exchanger •K Channels	•Na, 2 Cl,, K Uptake •Na Uptake and H Extrusion •K Extrusion
EarlyDCT	NaCl CT	Na & Cl Uptake
Late DCTCollecting Duct	Na Channel (ENaC)	Na Uptake

Conditions That Cause Large Increases in Blood Volume and Extracellular Fluid Volume

- Heart Diseases
- Increased Capacity of Circulation

Increases in Extracellular Fluid Volume but with Normal Blood Volume

- Nephrotic Syndrome
- Liver Cirrhosis