Renal Tubular Reabsorption and Secretion-II

Unit V

Chapter 28

Dr Iman Aolymat

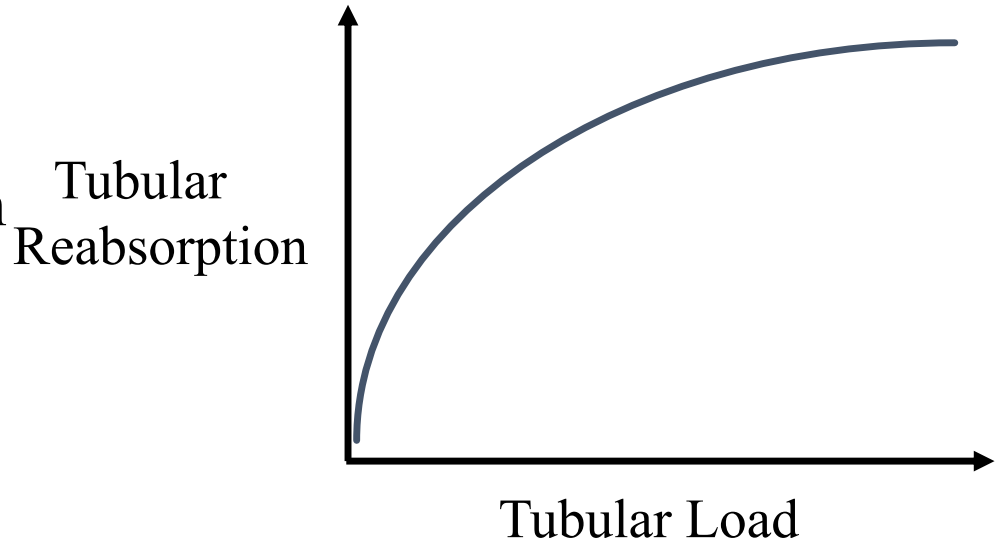
Regulation of Tubular Reabsorption

Regulation is required to maintain a precise balance between **tubular reabsorption** and **glomerular filtration**.

- Glomerulotubular Balance
- Peritubular Physical Forces
- Hormones
- Sympathetic Nervous System
- Arterial Pressure (pressure natriuresis)
- Osmotic factors.

Glomerulotubular Balance

- Intrinsic ability of tubules to ↑ **reabsorption** rate in response to ↑ tubular load if GFR↑ to 150 ml/min.
- In **proximal tubule** reabsorption ↑ from 81 ml/min to 97.5 ml/min
- To less extent in Loop of Henle.
- The mechanisms for glomerulotubular balance can occur **independently** of hormones.
- It helps to prevent overloading of the distal tubular segments when GFR increases.



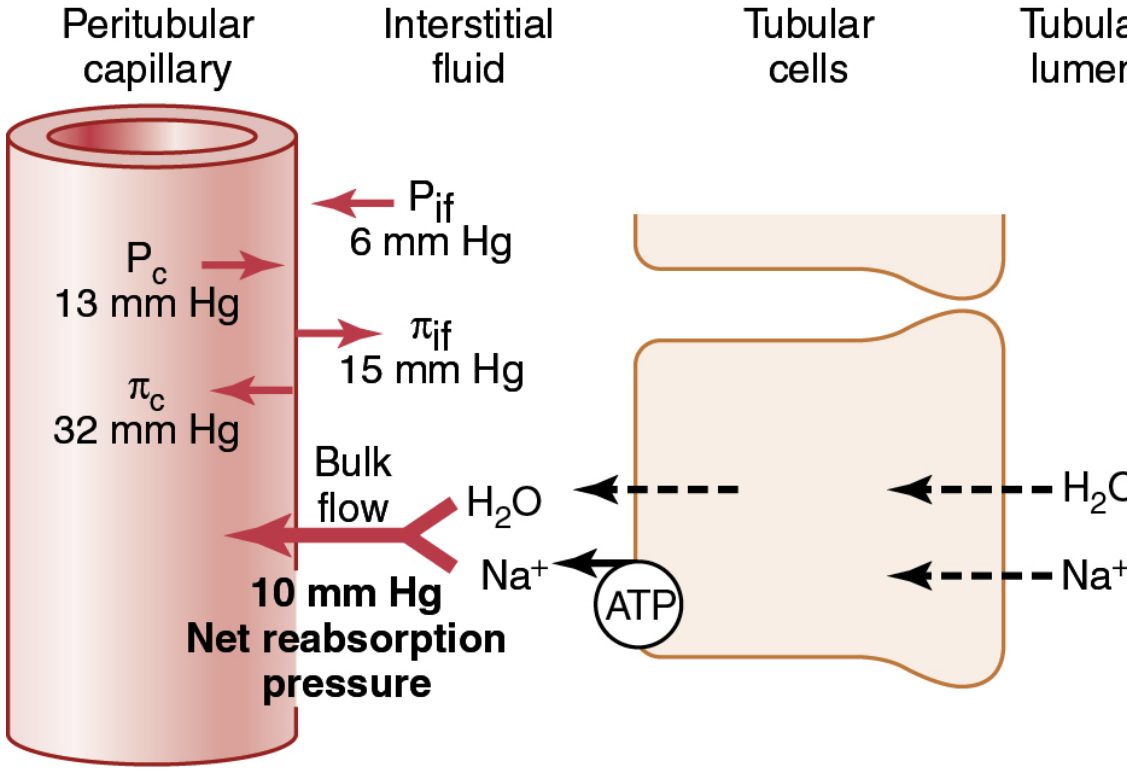
Peritubular Capillary Reabsorption

- Hydrostatic and colloid osmotic forces govern the rate of reabsorption across the peritubular capillaries
- Normal rate of peritubular capillary reabsorption is about 124 ml/min.

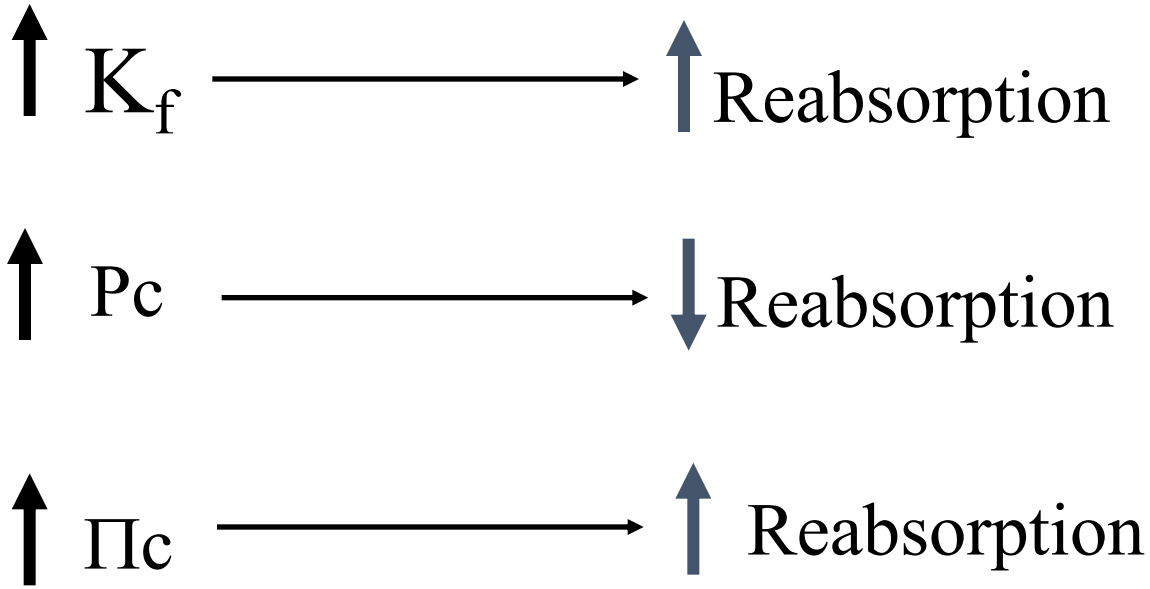
a. Hydrostatic P. in capillary (Pc) **opposes** -13
b. Hydrostatic P In interstitium (Pif) **favors** 6
c. Colloid osmotic P in capillary (πc) **favors** 32
d. Colloid osmotic P in intrst. (πif) **opposes** -15

Net reab. P 10 mmHg

Reabsorption = Kf x Net reabsorptive P
=12.4 x 10
= 124
ml/min

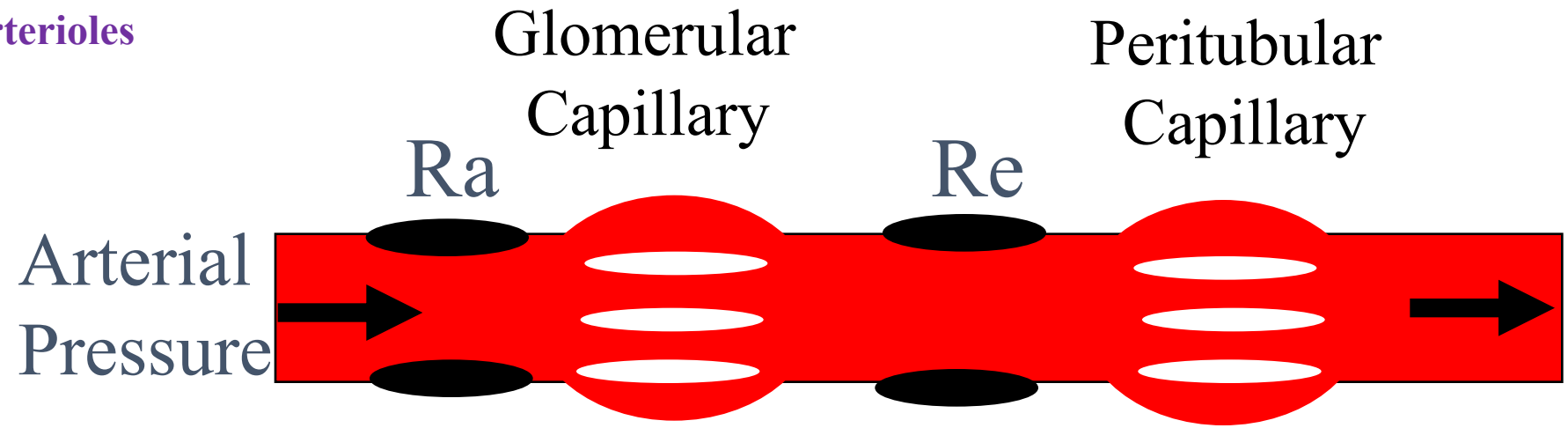


Determinants of Peritubular Capillary Reabsorption



Determinants of Peritubular Capillary Hydrostatic Pressure

P_C depends on BP, and resistance of aff. & eff. Arterioles



↑ Arterial Pressure → ↑ Pc → ↓ Reabs.

↑ Ra → ↓ Pc → ↑ Reabs.

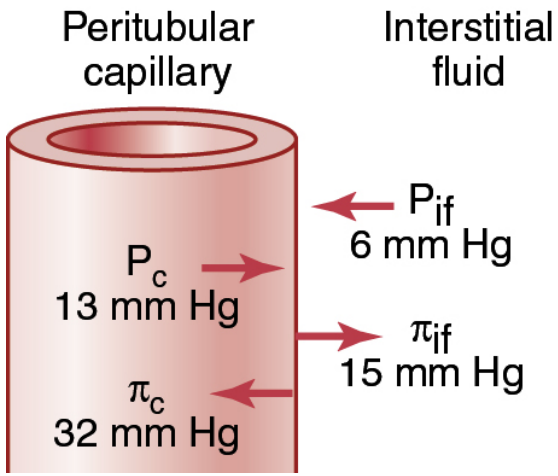
↑ Re → ↓ Pc → ↑ Reabs.

Determinants of Peritubular Capillary Colloid Osmotic Pressure

π_C depends: on [plasma protein]
& filtration fraction

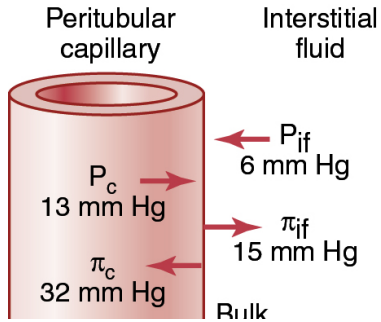
↑π_C → ↑Reabsorption
↑ [plasma protein] → ↑π_C → ↑Reabsorption
↑ FF→ ↑π_C → ↑Reabsorption

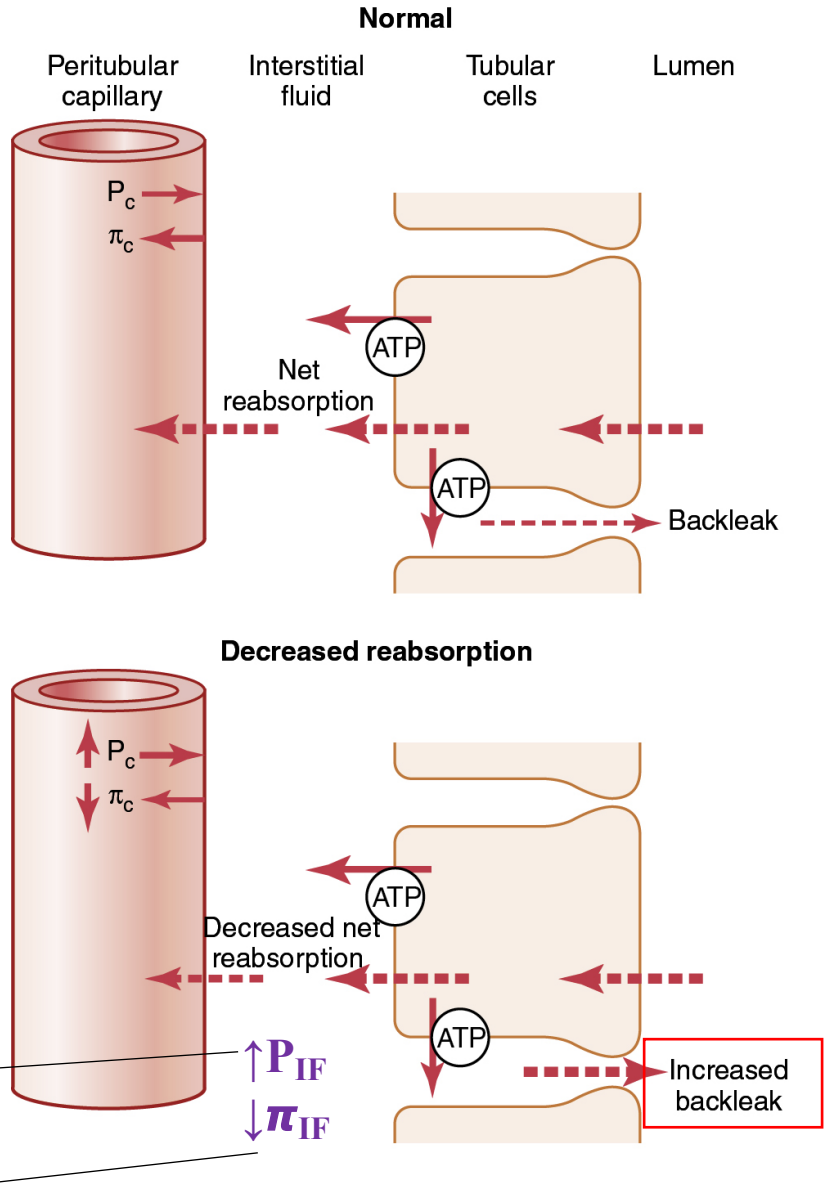
Filt. Fract. = GFR/RPF



In general, forces that increase peritubular capillary reabsorption also increase reabsorption from the renal tubules.

Conversely, hemodynamic changes that inhibit peritubular capillary reabsorption also inhibit tubular reabsorption of water and solutes





Pressure diuresis and pressure natriuresis

↑ BP → kidneys excrete large amounts of H2O & Na,

Even a slight increase in blood pressure doubles the water excretion.

diuresis & natriuresis→↓ECFV & blood volume→ brings the arterial blood pressure back to normal level.

factor that contributes to the pressure natriuresis and pressure diuresis:

1-Impaired autoregulation & ↑ GFR

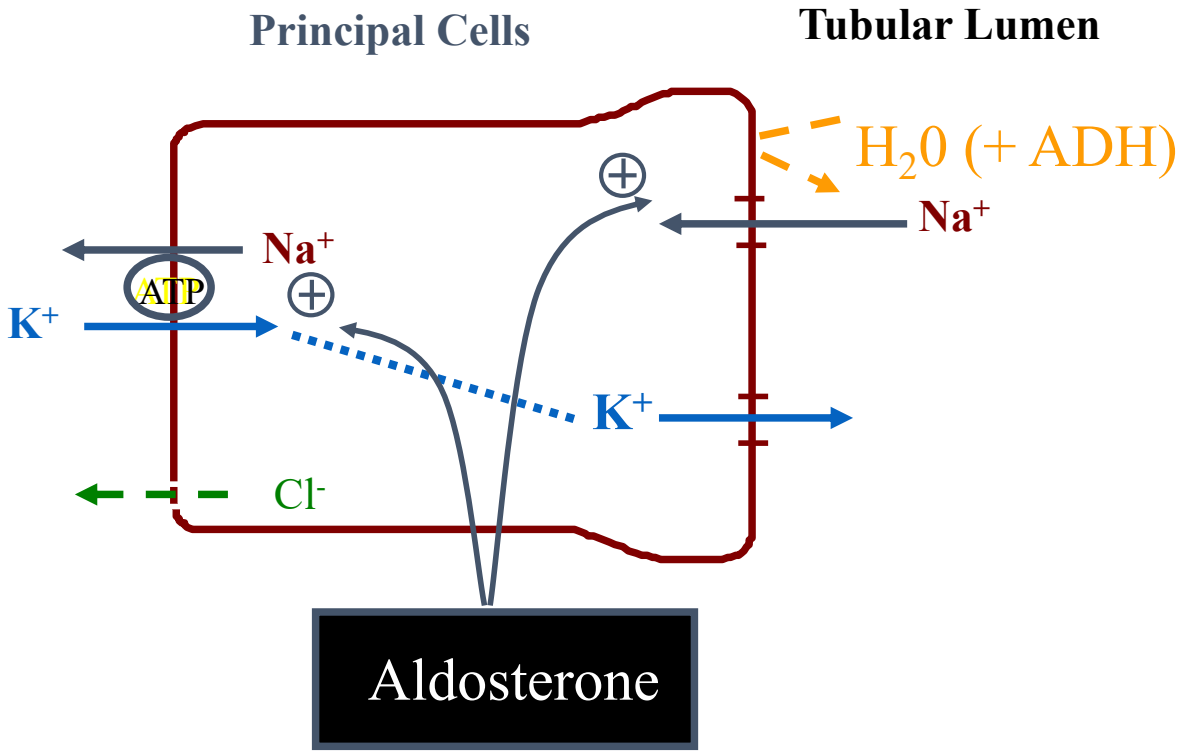
2- ↑ Pc in vasa recta→P_{if}→ prevent Na & H2O reabsorbtion+ backleak

3- ↓ Angiotensin II

Hormonal control of tubular reabsorption

Aldosterone actions on late distal, cortical and medullary collecting tubules

Aldosterone :
Secreted by adrenal cortex
Acts on the distal tubule and collecting ducts
Na Cl , H2O reabs.
Mainly acts on **principal calls** of cortical coll. tubule
increases K+ & H^+ secretion.



Control of Aldosterone Secretion

Factors that increase aldosterone secretion

- Angiotensin II
- Increased K^+
- adrenocorticotrophic hormone (ACTH) (permissive role)

Factors that decrease aldosterone secretion

- Atrial natriuretic factor (ANF)
- Increased Na^+ concentration (osmolality)

Abnormal Aldosterone Production

- Excess aldosterone (Primary aldosteronism Conn's syndrome) - Na^+ retention, hypokalemia, alkalosis, hypertension

- Aldosterone deficiency - Addison's disease Na^+ wasting, hyperkalemia, hypotension

Angiotensin II Increases Na^+ and Water Reabsorption

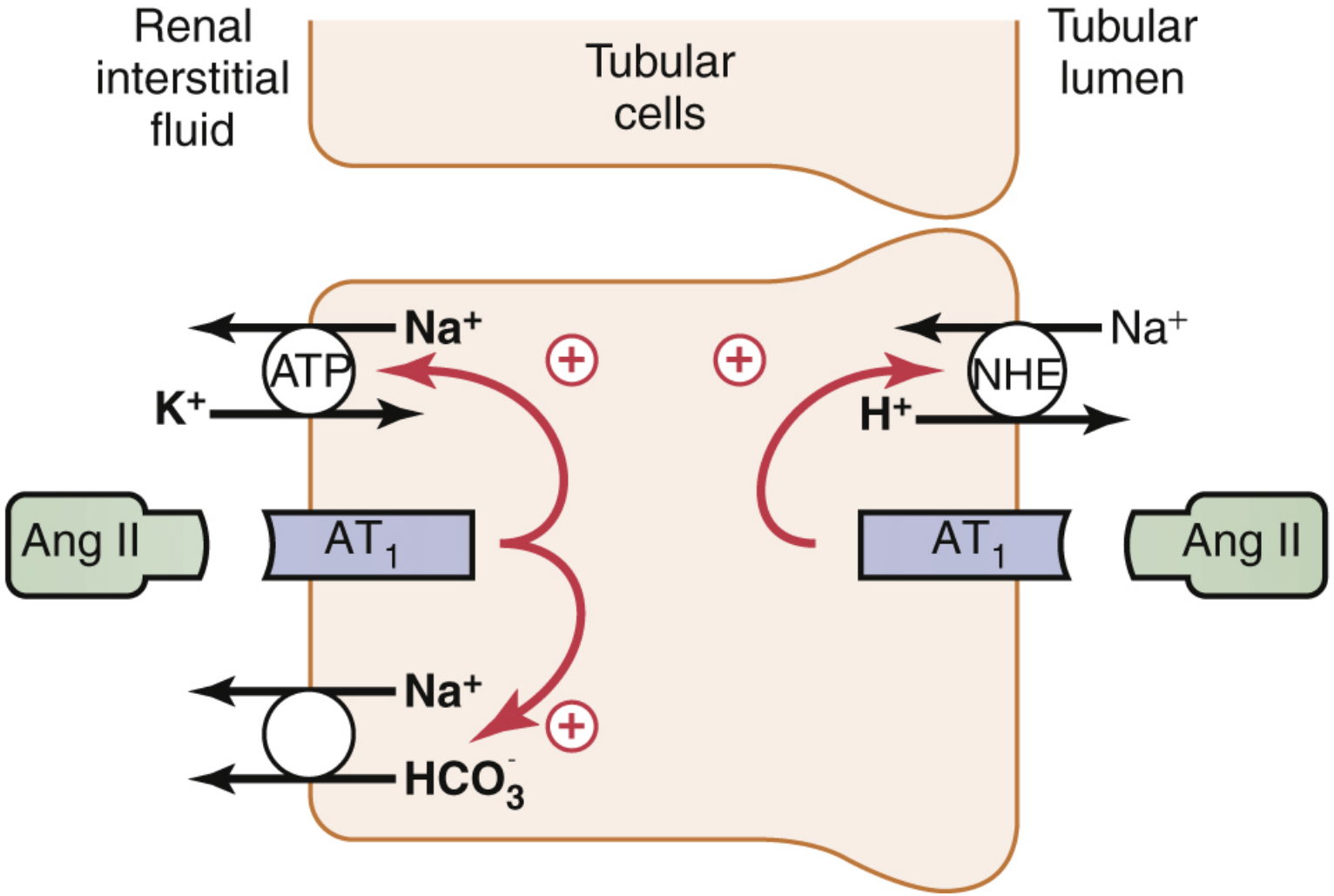
- low blood pressure and/or low ECFV

- Stimulates aldosterone secretion

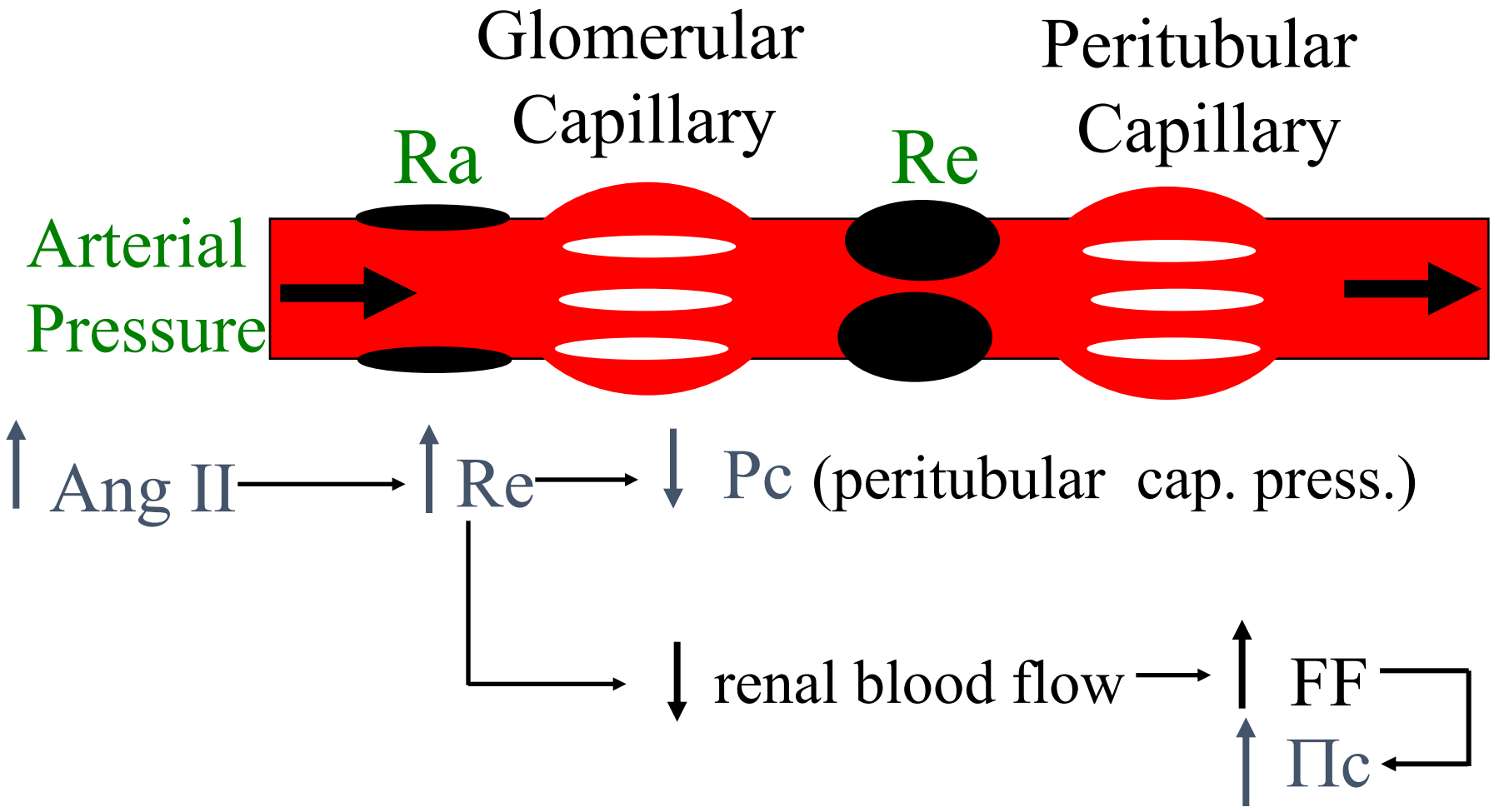
- Directly increases Na^+ reabsorption
  (proximal, loop, distal, collecting tubules)

- Constricts efferent arterioles
  - **decreases** peritubular capillary **hydrostatic pressure**
  - increases **filtration fraction**, which increases peritubular colloid osmotic pressure)

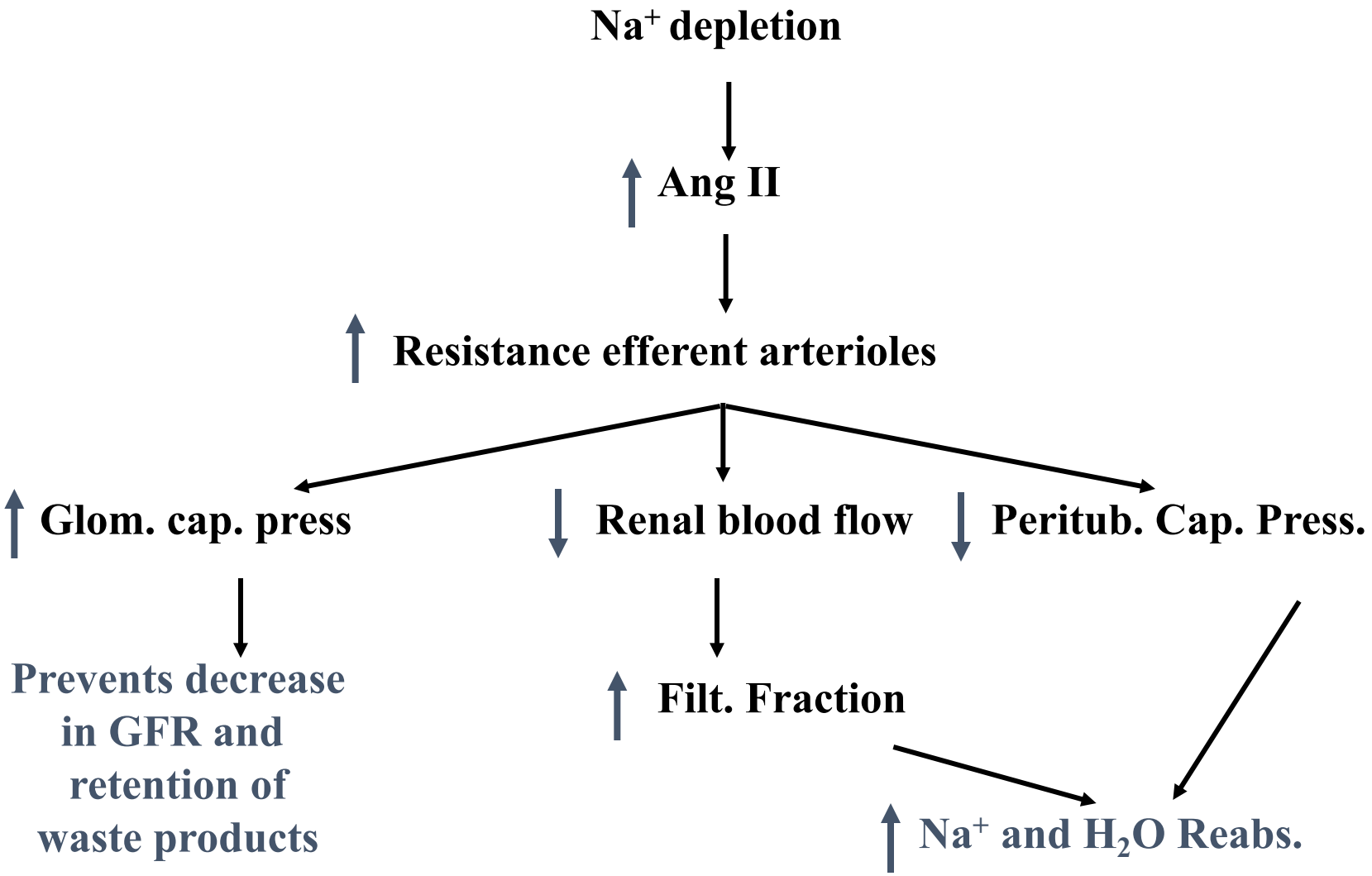
Angiotensin II increases renal tubular sodium reabsorption



Effect of Angiotensin II on Peritubular Capillary Dynamics



Ang II constriction of efferent arterioles causes Na^+ and water retention and maintains excretion of waste products



Angiotensin II blockade decreases Na^+ reabsorption and blood pressure

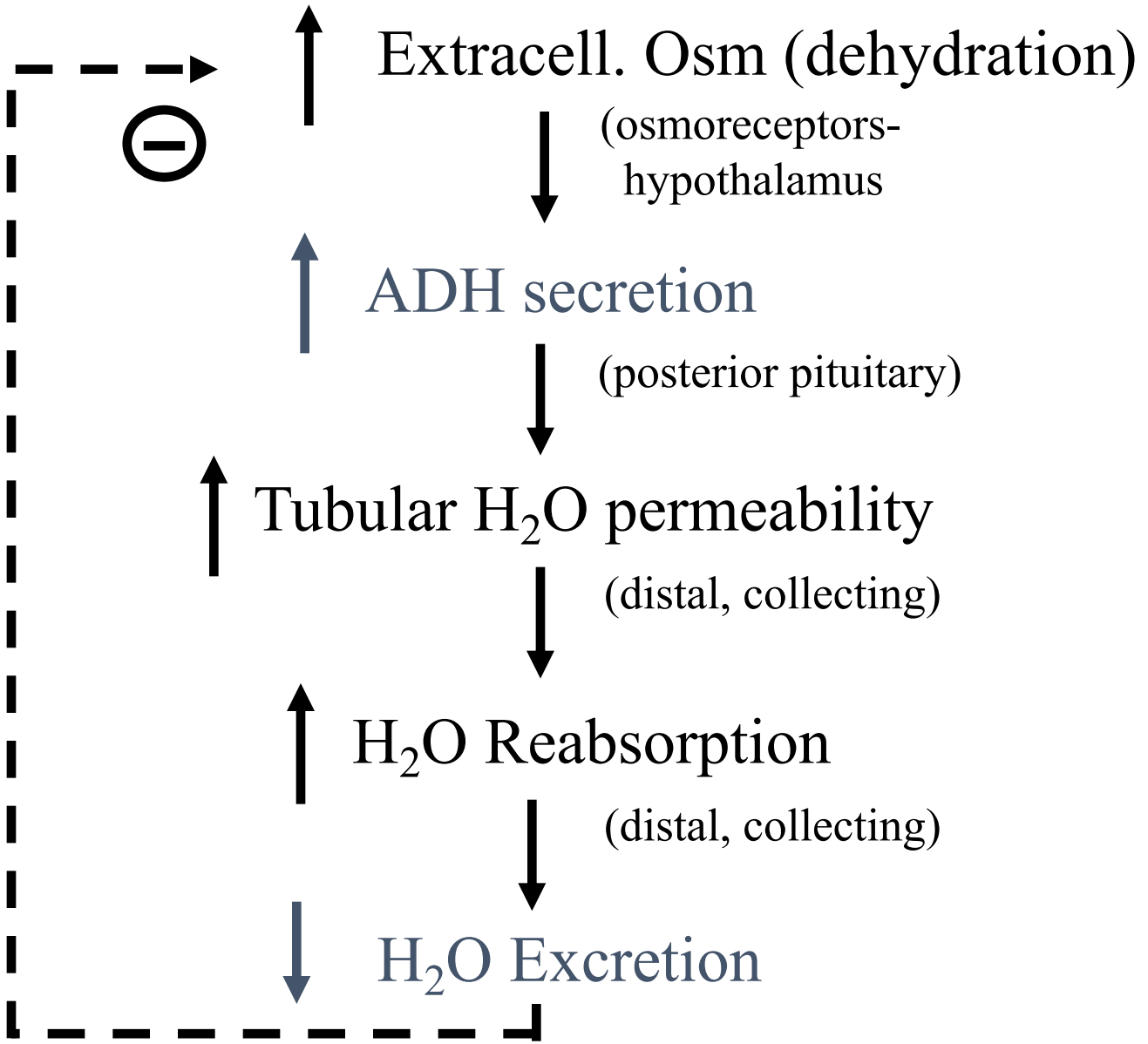
- ACE inhibitors (captopril, benazipril, ramipril)
- Ang II antagonists (losartan, candesartin, irbesartan)
- Renin inhibitors (aliskirin)
  - decrease aldosterone
  - directly inhibit Na^+ reabsorption
  - decrease efferent arteriolar resistance

Natriuresis and Diuresis + ↓ Blood Pressure

Antidiuretic Hormone (ADH)

- Secreted by posterior pituitary
- Increases H_2O permeability and reabsorption in **distal and collecting tubules**
- Allows differential control of H_2O and solute excretion
- Important controller of extracellular fluid osmolarity

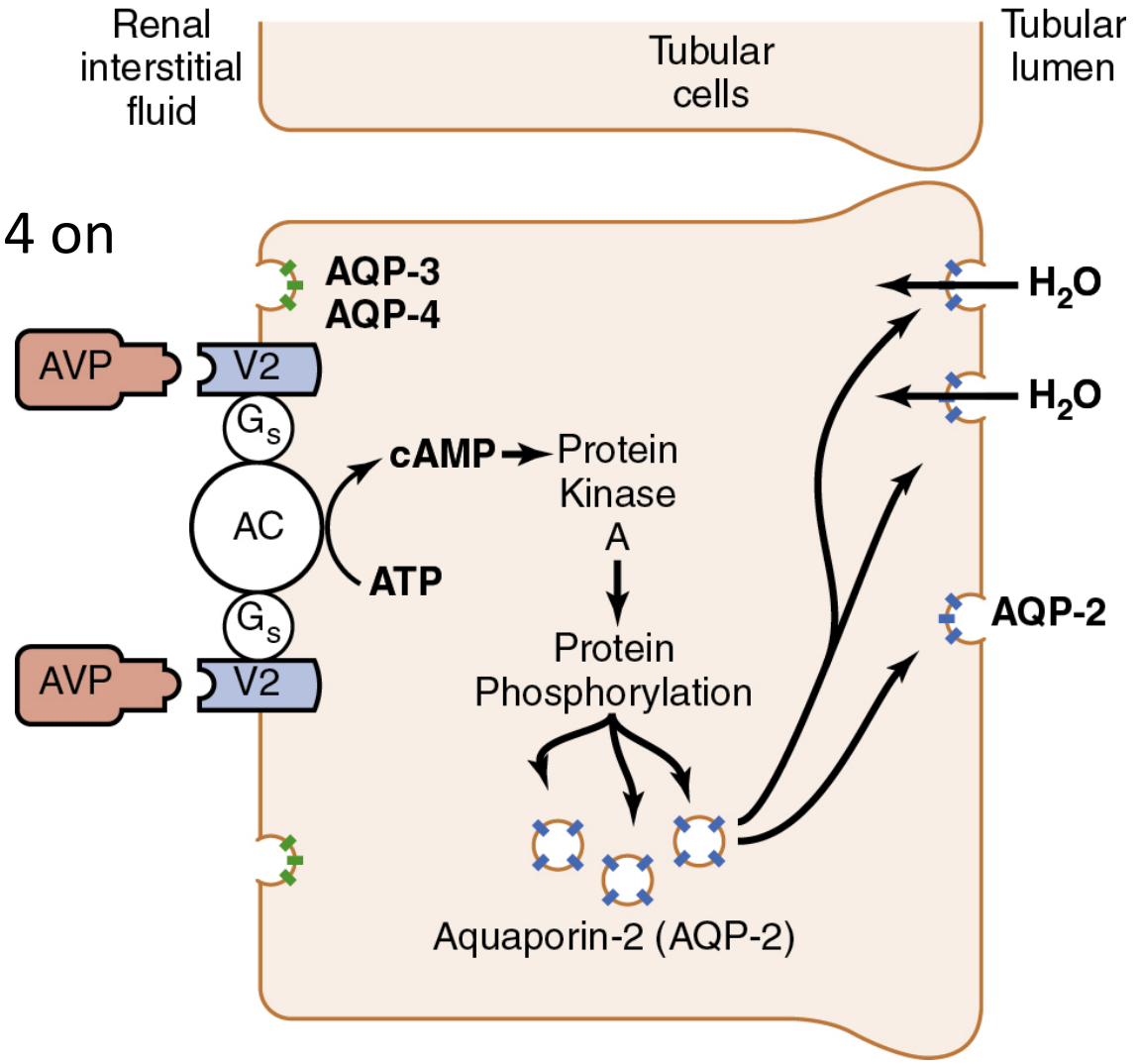
Feedback Control of Extracellular Fluid Osmolarity by ADH



Mechanism of action of ADH in distal and collecting tubules

Binds V2 receptors→form cyclic AMP →increase aquaporin-2 on luminal, AQP3,4 on basolateral

- When ADH decreased→AQP back to cytoplasm



Abnormalities of ADH

- Inappropriate ADH syndrome (excess ADH)
  - decreased plasma osmolarity, hyponatremia

- "Central" Diabetes insipidus (insufficient ADH)
  - water loss (diluted urine), increased plasma osmolarity, hypernatremia, excess thirst

Desmopressin ttt

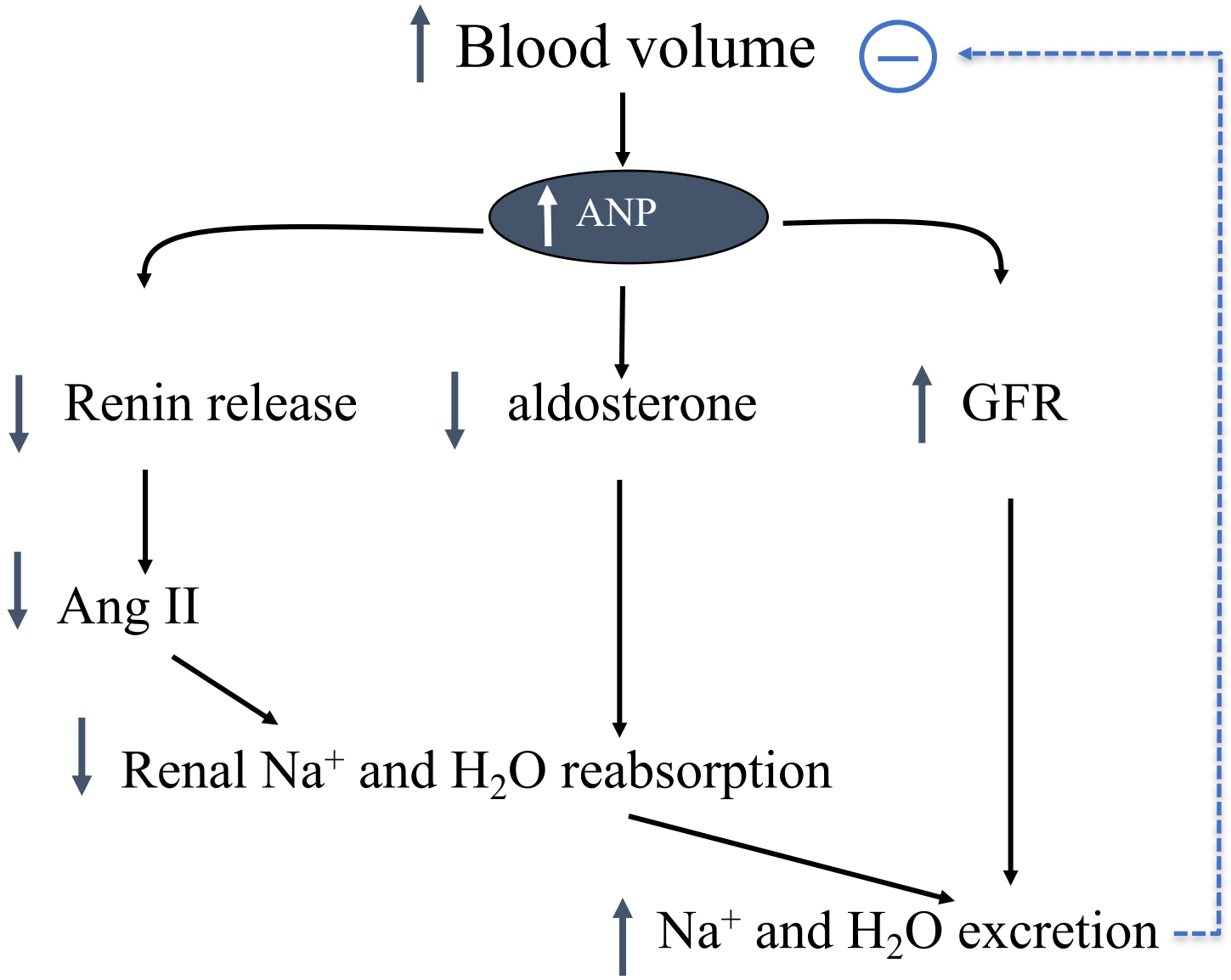
Abnormalities of ADH

- Failure of kidneys to respond to ADH:
  "nephrogenic" diabetes insipidus → failure of countercurrent mechanism to form a hyperosmotic renal medullary interstitium/ failure of the distal and collecting tubules and collecting ducts to respond to ADH.

  - impaired loop NaCl reabs. (loop diuretics)
  - drug induced renal damage: lithium, analgesics
  - malnutrition (decreased urea concentration)
  - kidney disease: pyelonephritis, hydronephrosis, chronic renal failure

Atrial natriuretic peptide increases Na^+ excretion

- Secreted by cardiac atria in response to stretch (increased blood volume)
- Directly inhibits Na^+ reabsorption (mainly from **collecting ducts)**
- Inhibits renin release and aldosterone formation
- Increases GFR
- Helps to minimize blood volume expansion


↑ Blood volume
⊖
↑ ANP
↓ Renin release
↓ aldosterone
↑ GFR
↓ Ang II
↓ Renal Na^+ and H_2O reabsorption
↑ Na^+ and H_2O excretion

Parathyroid hormone increases renal Ca^{++} reabsorption

- Released by parathyroids in response to decreased extracellular Ca^{++}
- Increases Ca^{++} reabsorption by kidneys
- Increases Mg^{++} reabsorption by kidneys
- Decreases phosphate reabsorption
- Helps to increase extracellular Ca^{++}

Table 28-3 Hormones That Regulate Tubular Reabsorption

Hormone	Site of Action	Effects
Aldosterone	Collecting tubule and duct	↑ NaCl, H_2O reabsorption, ↑ K^+ secretion, ↑ H^+ secretion
Angiotensin II	Proximal tubule, thick ascending loop of Henle/distal tubule, collecting tubule	↑ NaCl, H_2O reabsorption, ↑ H^+ secretion
Antidiuretic hormone	Distal tubule/collecting tubule and duct	↑ H_2O reabsorption
Atrial natriuretic peptide	Distal tubule/collecting tubule and duct	↓ NaCl reabsorption
Parathyroid hormone	Proximal tubule, thick ascending loop of Henle/distal tubule	↓ PO_4^- reabsorption, ↑ Ca^{++} reabsorption

Sympathetic nervous system increases Na^+ reabsorption

- Directly stimulates Na^+ reabsorption
- Stimulates renin release
- Decreases GFR and renal blood flow (only a high levels of sympathetic stimulation)

Questions?
The End