Urine Concentration Mechanism

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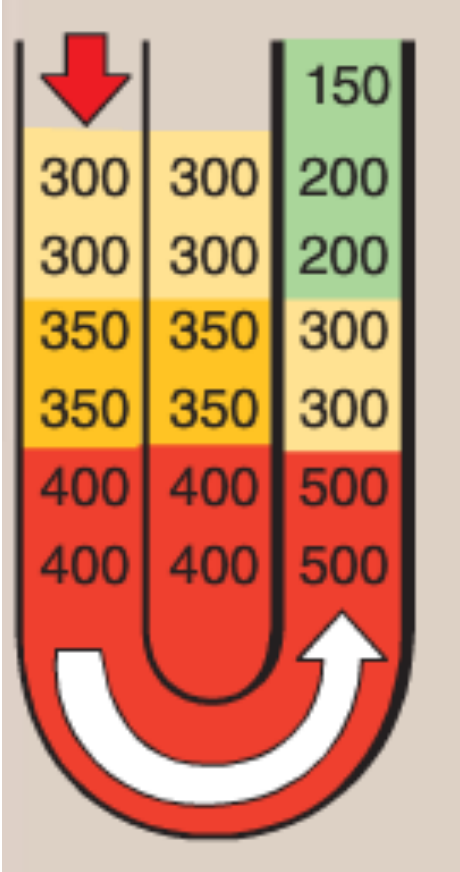
Learning Objectives:

- Identify and describe that the loop of Henle is referred to as countercurrent multiplier and the loop and vasa recta as countercurrent exchange systems in concentrating and diluting urine
- Explain what happens to osmolarity of tubular fluid in the various segments of the loop of Henle when concentrated urine is being produced.
- Explain the factors that determine the ability of loop of Henle to make a concentrated medullary gradient
- Differentiate between water diuresis and osmotic diuresis
- Appreciate clinical correlates of diabetes mellitus and diabetes insipidus

Countercurrent System

- A system in which inflow runs parallel and in close proximity but opposite to the outflow.



Mechanism for urine concentration/dilution

- While the **loop of Henle** reabsorbs another 20% of the salt/water in tubular fluid, primary function is to determine osmolarity of urine (i.e. whether concentrated or diluted) using

countercurrent multiplier system

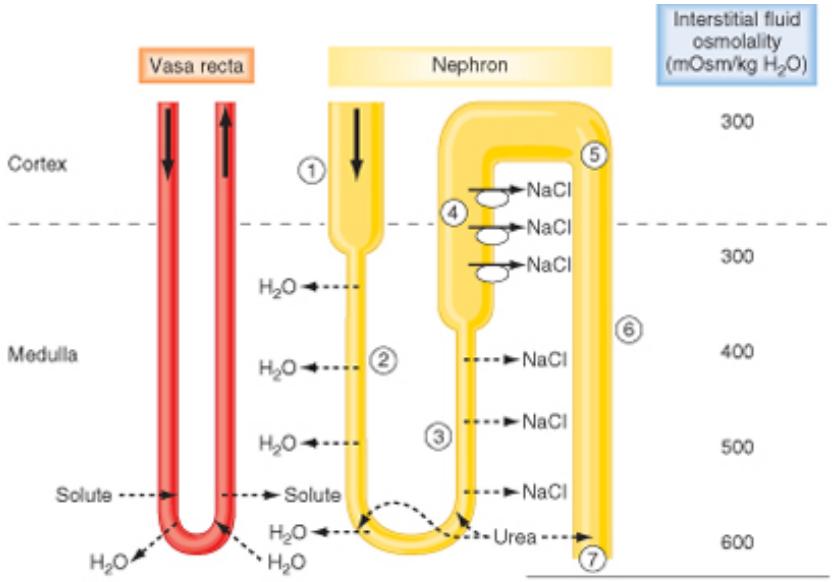
- While collecting duct is where urine concentration is determined, osmolarity of interstitial fluid in medulla must be high and osmolarity of tubular fluid must be low
  - Countercurrent multiplier system achieves this

Countercurrent multiplier system

- Is the repetitive reabsorption of NaCl by the thick ascending loop of Henle and continued inflow of new NaCl from PCT into LOH
- The NaCl reabsorbed from the ascending LOH keeps adding newly arrived NaCl (into LOH from PCT), thus multiplying its concentration in the medulla

How the kidney excrete dilute urine ?

- Dilution (low or no ADH):
- Reabsorb solute don't absorb water
- 1) Isoosmotic fluid from PCT
- 2) Thin descending limb permeable to water, less for NaCl
- ∴ water reabsorbed, tubule osomolality = medulla (i.e. high)



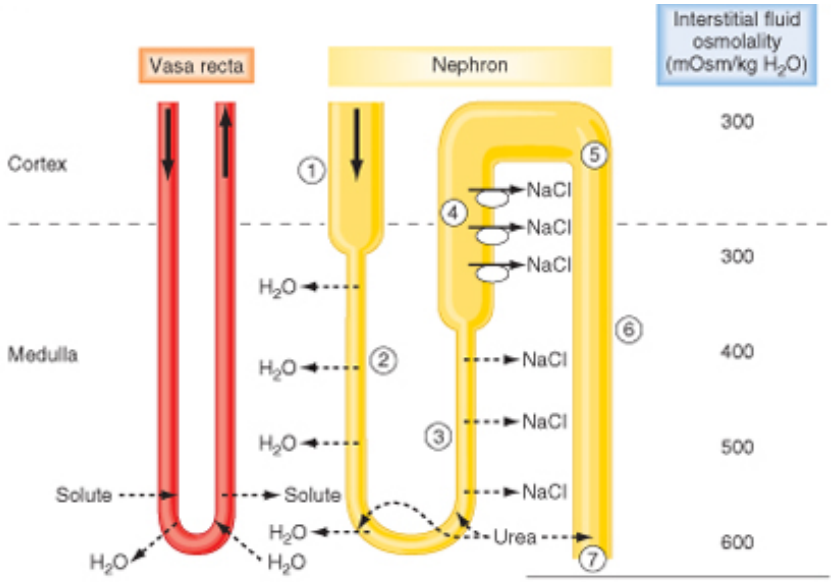
How the kidney excrete dilute urine ?

3) Thin ascending limb impermeable to water, permeable to NaCl (passive)

- tubule volume unchanged, [NaCl] ↓

4) TAL impermeable to water, NaCl actively reabsorbed (diluting segment of nephron)

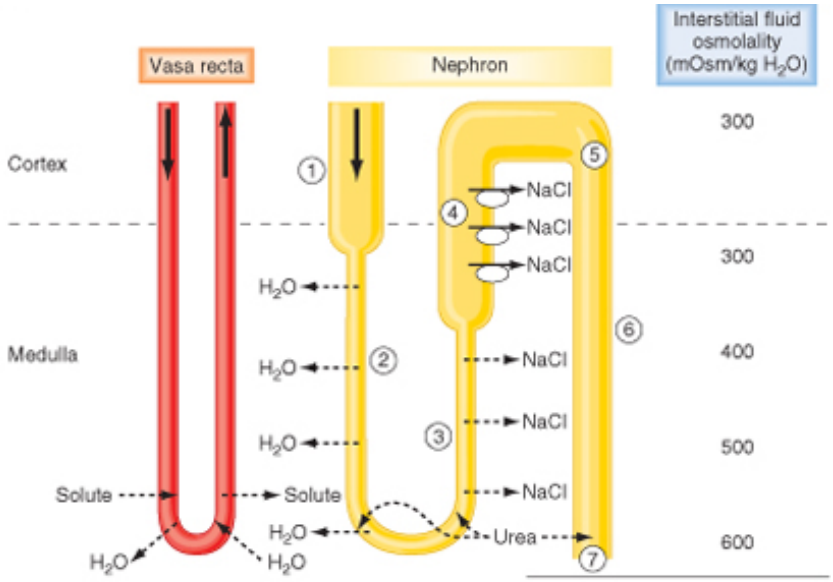
- diluting tubule fluid 150 mOsm/kg water



How the kidney excrete dilute urine ?

5) Collecting duct reabsorb NaCl

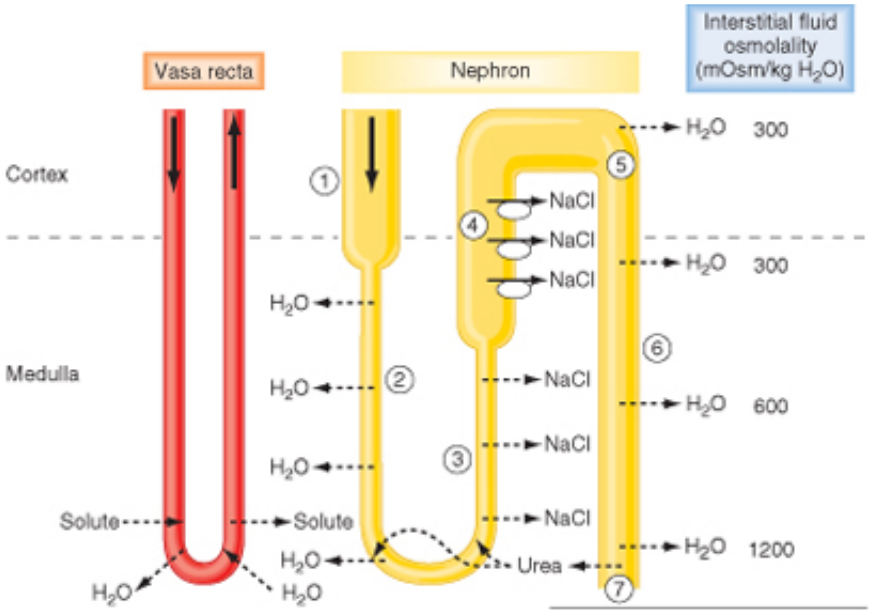
- ↓ osmolality, may reach 50 mOsm/kg water



How the kidney excrete concentrated urine ?

- Concentration of urine (ADH dependent):

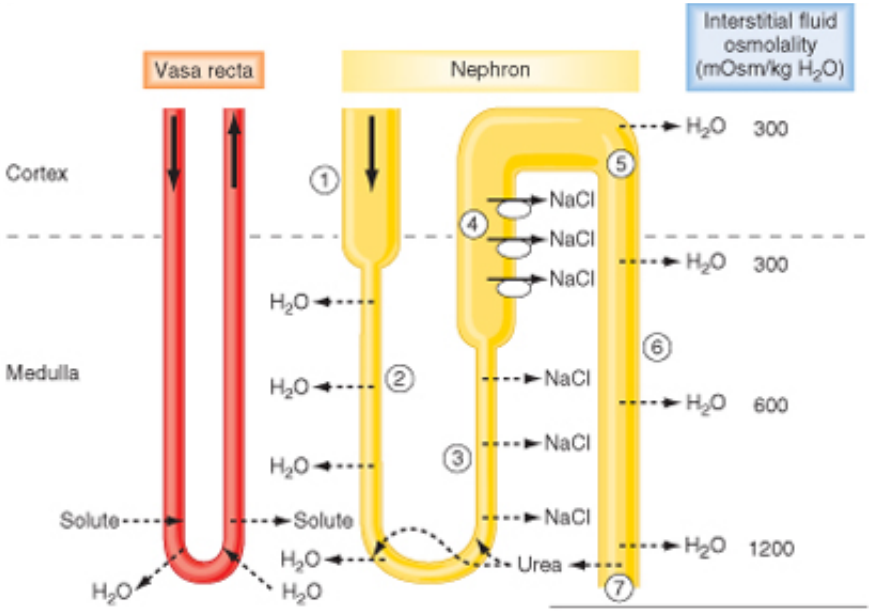
- 1-4 same as dilution
- Reabsorbed NaCl in loop of Henle ⇒ ↑ osmolality of interstitium
- Generated by **Countercurrent Multiplication**



How the kidney excrete concentrated urine ?

5) Fluid reaching CD hypoosmotic (osm due urea)

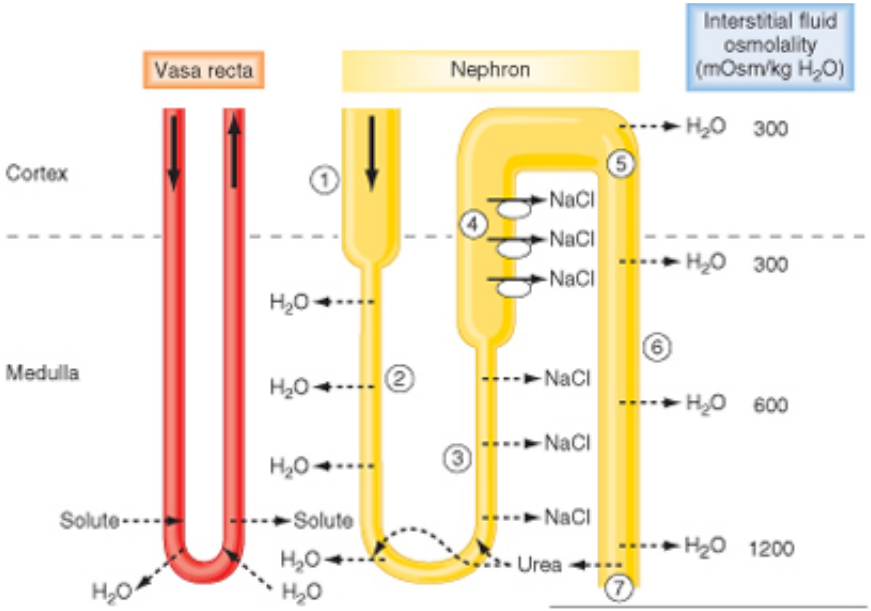
- ADH causes water to diffuse out up to a max of 300 mOsm/kg water



How the kidney excrete concentrated urine ?

6) Osmolality of medullary tissue high up to 1200 mOsm/kg water

- due to NaCl (accounts for 600)
- urea (accounts for 600)
- early CD impermeable to urea
- ADH allows water reabsorption passively



How the kidney excrete concentrated urine ?

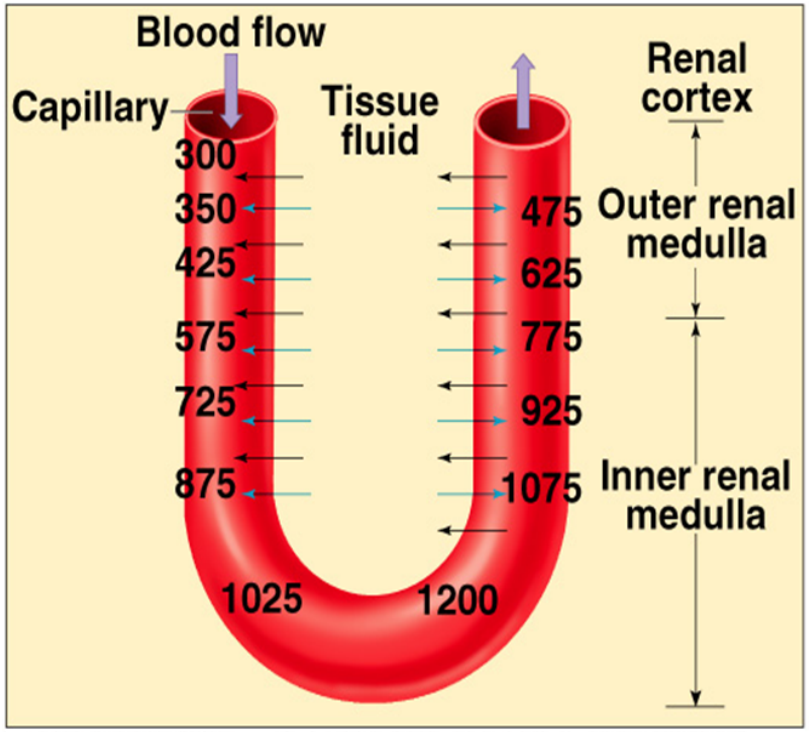
- When ADH levels high urea levels in medullary CD & interstitium equilibrate
- Most water absorbed in presence of ADH is in the cortical collecting duct

Countercurrent exchange in the Vasa Recta

- There are two special features of the renal medullary blood flow that contribute to the preservation of the high solute concentration:

1. **The medullary blood flow is low,** accounting for less than 5% of the renal blood flow. This sluggish blood flow is sufficient to supply the metabolic needs of the tissues but helps to minimize solute loss from the medullary interstitium
2. **The vasa recta serve as countercurrent exchanger,** minimizing washout of solutes from the medullary interstitium.

- **<u>The vasa recta do not create the medullary hyperosmolarity, but they do prevent from being dissipated</u>**



Black arrows = diffusion of NaCl and urea
Blue arrows = movement of water by osmosis


Thanks