Renal Blood flow; Renal Clearance

Dr Sitelbanat

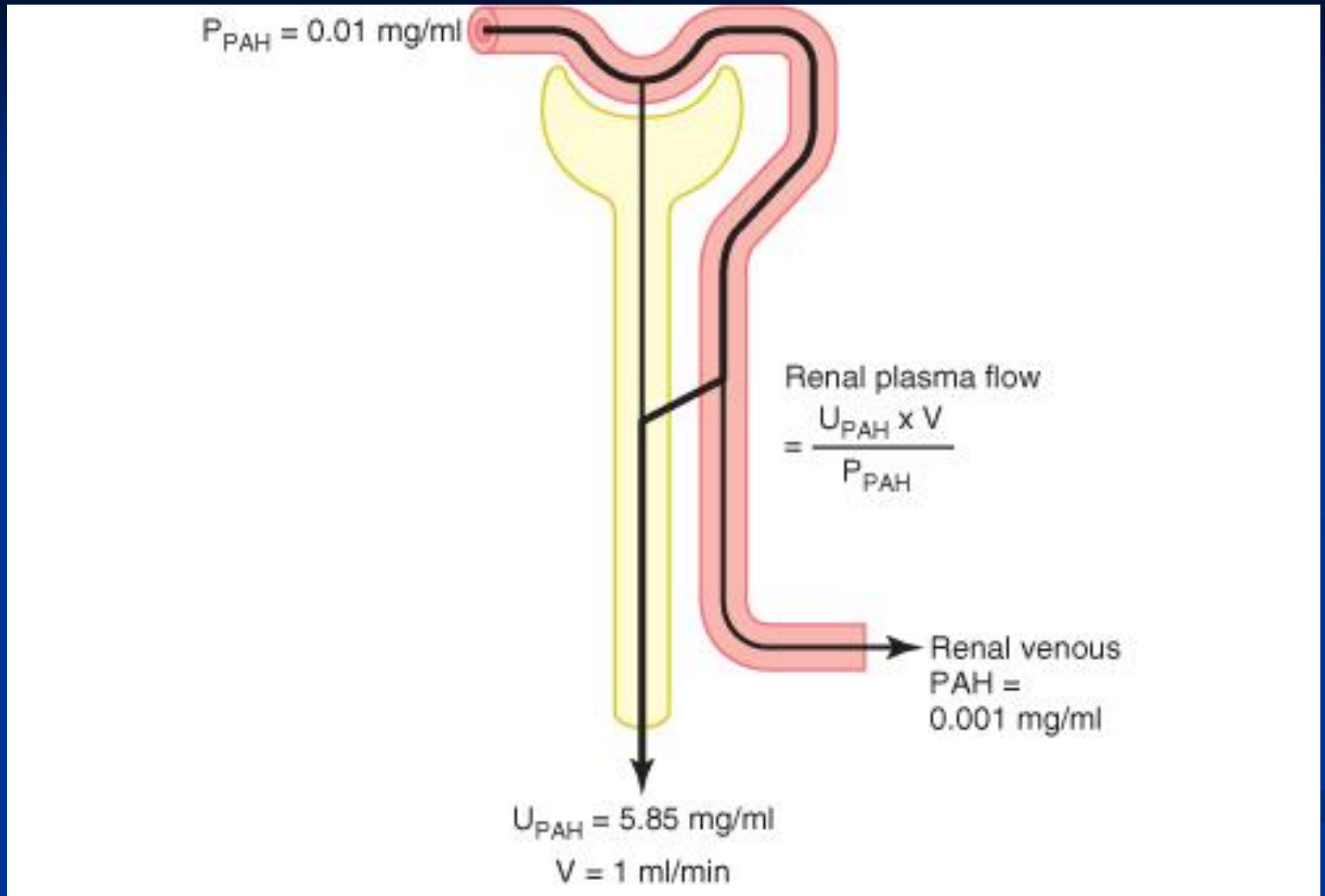
Objectives

At the end of this lecture student should be able to describe:

- **Renal blood flow**
- **Autoregulation of GFR and RBF**
- **Regulation of GFR**
- **The Calcuation of Clearance**

Renal Blood flow

- In average adult RBF = 1.1l/min
- PAH an organic acid used for measurement of RBF
- In one renal circulation/min PAH is almost completely removed (90%) from the plasma & excreted in urine
- PAH clearance = volume of plasma cleared from PHA/min = RPF/min



Use of PAH Clearance to Estimate Renal Plasma Flow

Paraminohippuric acid (PAH) is freely filtered and secreted and is almost completely cleared from the renal plasma

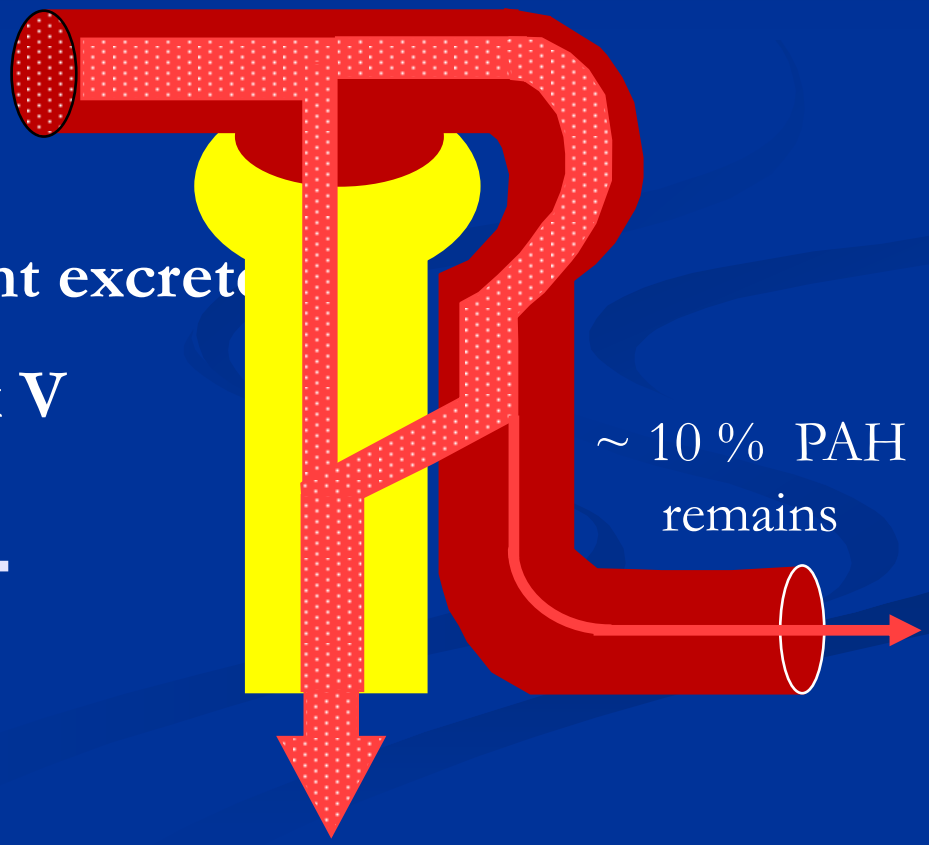
1. amount enter kidney = $RPF \times P_{PAH}$

2. amount entered $\tilde{=}$ amount excrete

3. $ERPF \times P_{pah} = U_{PAH} \times V$

$$ERPF = \frac{U_{PAH} \times V}{P_{PAH}}$$

ERPF = Clearance PAH



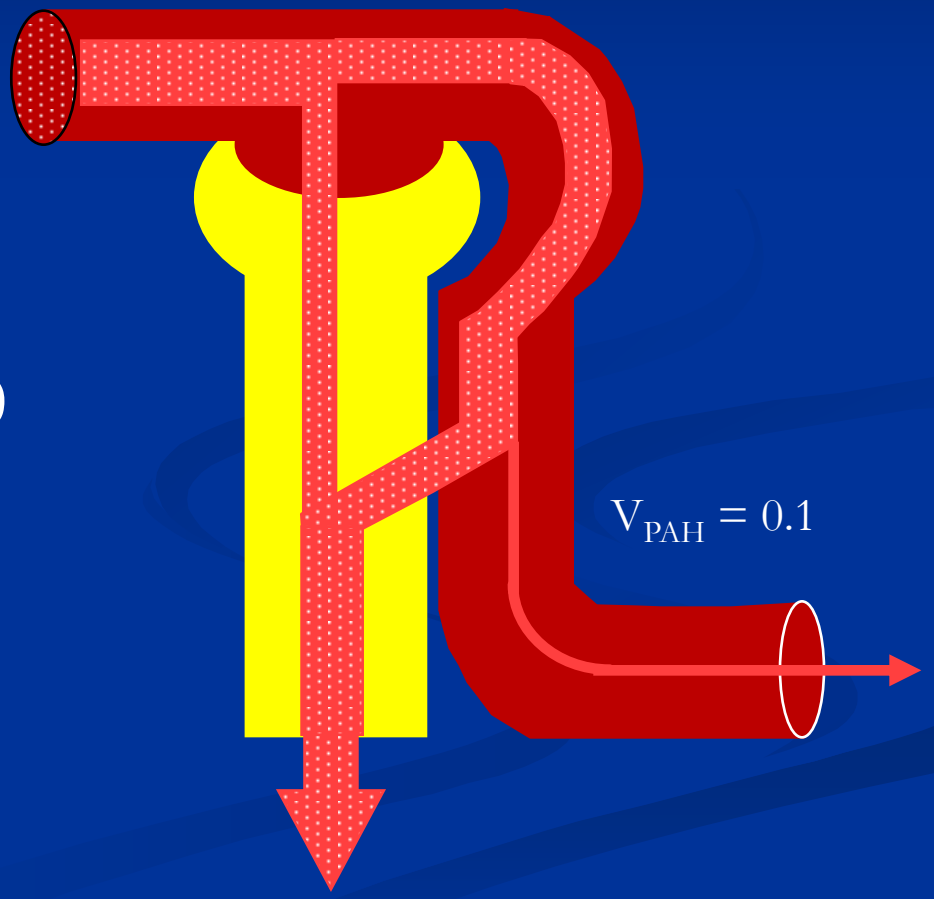
To Calculate Actual RPF , One Must Correct for Incomplete Extraction of PAH(extraction ratio)

$E_{PAH} = 0.9$

PAH is 90 % extracted

ARPF = ERPF /90 =100

RBF = ARPF /55 *100



Calculation of renal blood flow

- RPF= the amount of a PAH excreted per unit time
- 90% of PAH in arterial blood is removed by the kidney
- Clearance of PAH = $\frac{[U]_{PAH} \times V_{min}}{[P]_{PAH}}$ = 630ml/min
- =effective renal plasma flow (ERPF)

Calculation of renal blood flow *cont.*

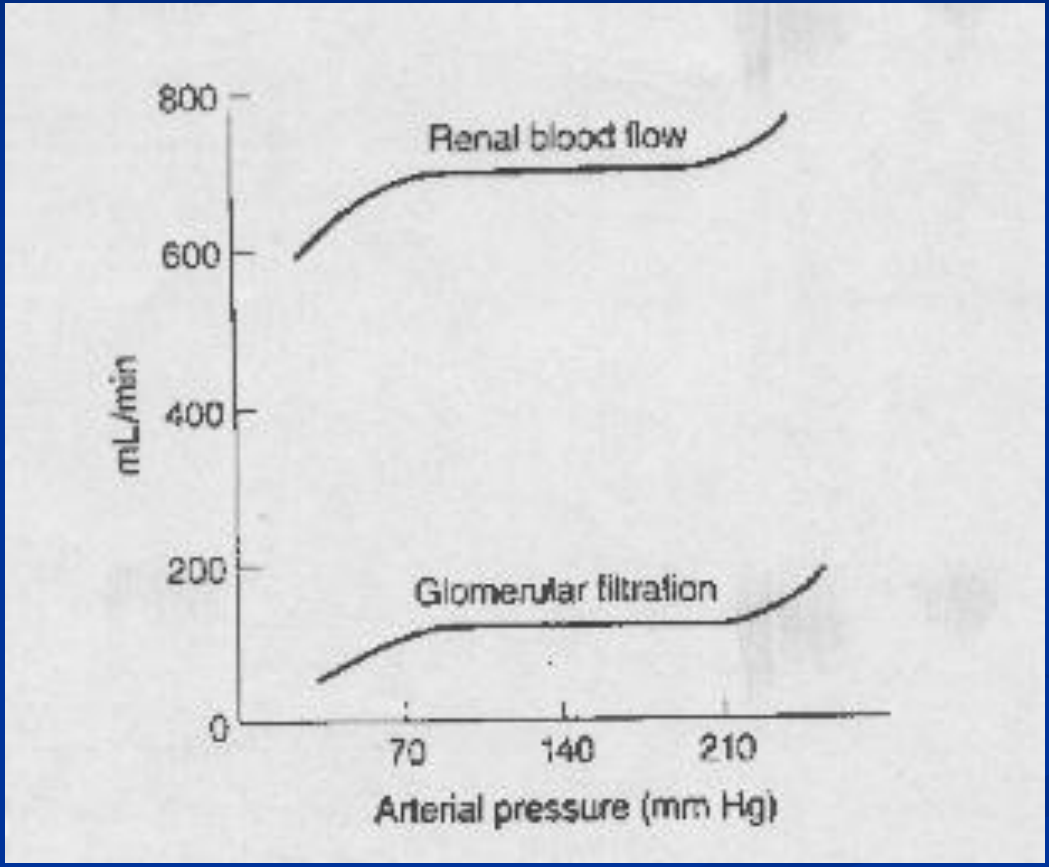
- Actual renal plasma flow (RPF) = ERPF/ extraction ratio = 630 / 90 * 100 = 700ml/min
- Calculate the renal blood flow (RPF)

  = 700/55 * 100 = 1.2 l/min

Autoregulation

- Feed back mechanism to keep RBF and GFR relatively constant despite marked changes in ABP
- Range of autoregulation is between 75-160 mmHg ABP
- < 60 mmHg → ↓ GFR → Kidney shut down

Autoregulation of GFR & RBF



Autoregulation of GFR

- Changes diameters of afferent, efferent arteriole, and glomerular capillaries
  - drop pressure results in dilation of afferent arteriole, dilation of glomerular capillaries and constriction of efferent arteriole.
  - Rises in pressure results in constriction of afferent arteriole.

Three processes controlling GFR

1. Myogenic autoregulation
2. Hormonal regulation (tubuloglomerular & renin-angiotensin)
3. Autonomic regulation (extrinsic)

1. Myogenic autoregulation

- The ability of blood vessels to resist stretching

- ↑ hydrostatic Pressure → stretching vessels wall → reflex contraction

2. Hormonal Regulation

- Tubuloglomerular feedback
- Renin-angiotensin Aldsterone
- Other Hormones

Tubuloglomerular feedback

- ↓ GFR → slow flow → ↑ Nacl reabsoption → ↓ Nacl at macula densa:
  1. ↑ renin → ↑ angiotensin II → efferent vasoconstriction → ↑ GFR
  2. Afferent dilation → ↑ GFR ?

Renin-angiotensin Aldsterone

- Renin is released into plasma
  - low ECF Na or low ECV
  - ↑ sympathetic (hypotension)
  - ↓ afferent pressure
- Renin acts on angiotensinogen → Angiotensin I
- Angiotensin converting enzyme (ACE): Angiotensin I → angiotensin II
- angiotensin II act on adrenal cortex → aldosterone secretion→ ↑ Na reabsorption in distal & collecting duct of nephron
- ↑ H and K secretion in exchange for Na

Other Hormonal Regulator of GFR

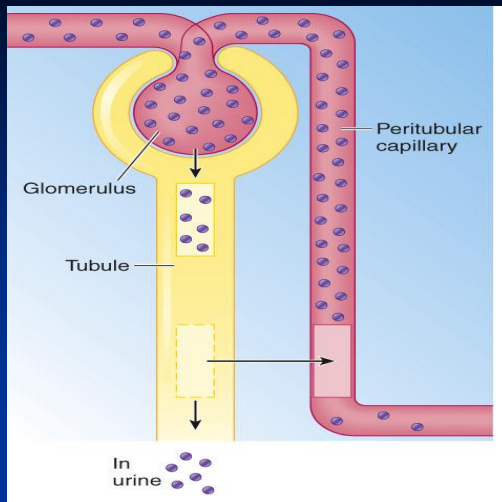
1. Adrenaline, noradrenaline → affarent vasoconstriction → ↓ GFR
2. Angiotensin II→ Vasoconstriction of efferent → ↑ GFR
3. Prostaglandins, bradykinin affarent vasodilator → ↑ GFR

Autonomic Regulation of GFR

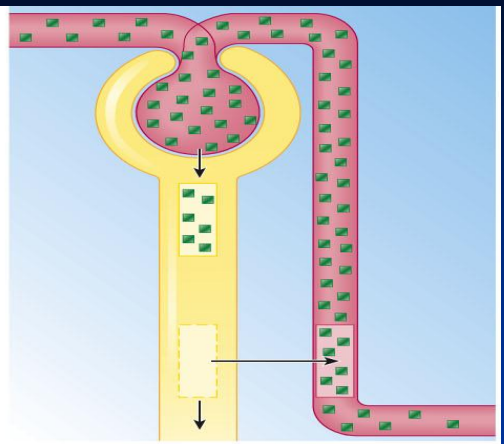
- In normal condition Sympathetic NS has little influence on GFR
- ↓ BP (hemorrhage) → ↑ sympathetic → vasoconstriction of renal artery → ↓ RBF → vasoconstriction of afferent → ↓ GFR TO DIVERT BLOOD TO VITAL ORGANS

Clearance

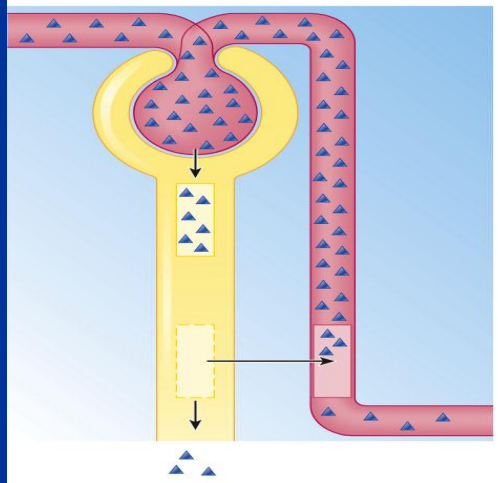
- volume of plasma completely cleared of a substance by both kidneys per unit time
- Clearance equation
  - $C = \frac{[U]_s \times V/min}{[P]_s} = ml/min$
- Renal clearance for different substances various between 0-600ml/min



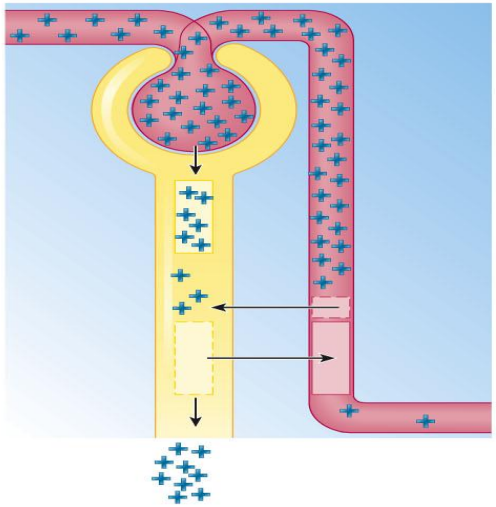
(a) For a substance filtered and not reabsorbed or secreted, such as inulin, all of the filtered plasma is cleared of the substance.



(b) For a substance filtered, not secreted, and completely reabsorbed, such as glucose, none of the filtered plasma is cleared of the substance.



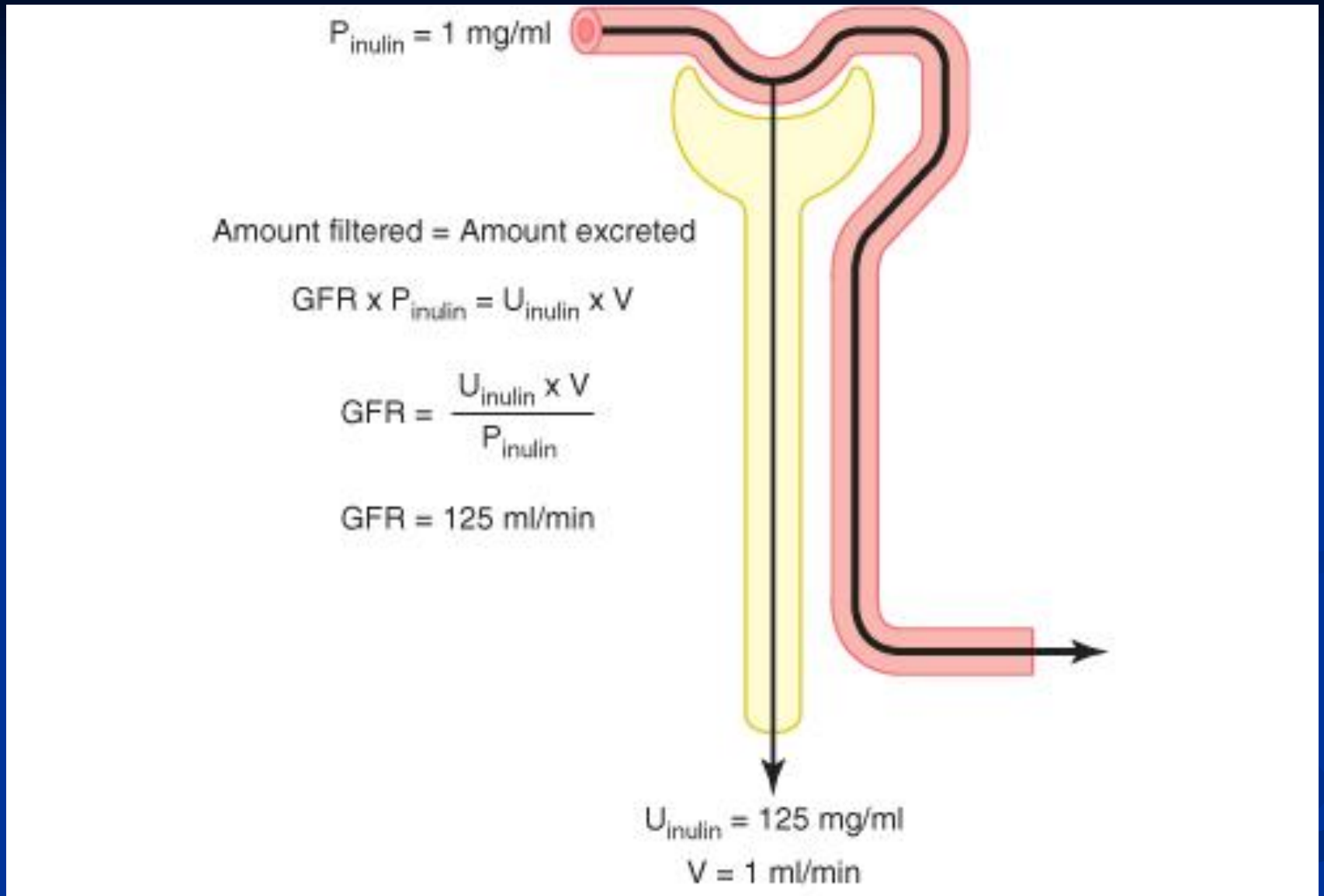
(c) For a substance filtered, not secreted, and partially reabsorbed, such as urea, only a portion of the filtered plasma is cleared of the substance.



(d) For a substance filtered and secreted but not reabsorbed, such as hydrogen ion, all of the filtered plasma is cleared of the substance, and the peritubular plasma from which the substance is secreted is also cleared.

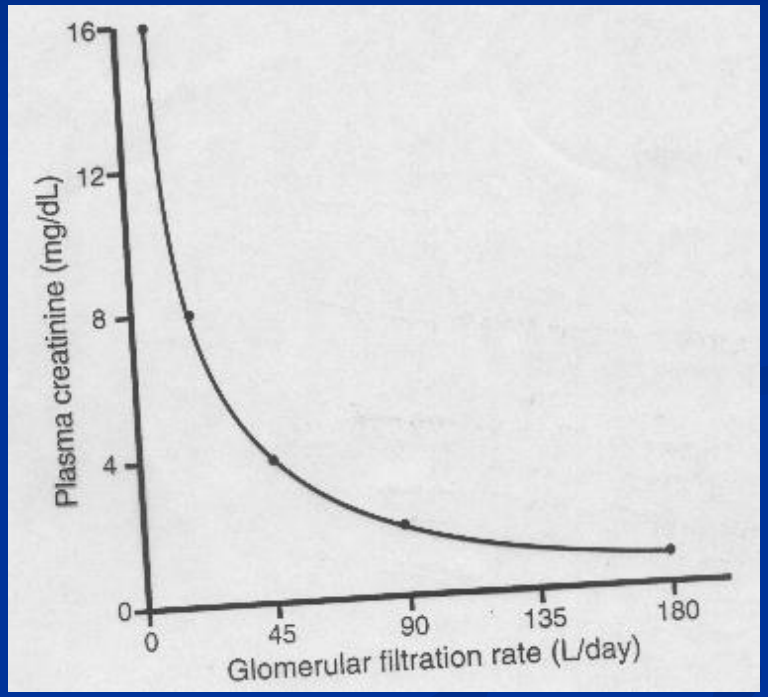
Inulin clearance & GFR

- 125 ml/min
- As inulin is
  - freely filtered
  - not reabsorbed or secreted
- Inulin clearance = GFR



Creatinine clearance &GFR

- Creatinine is an endogenous substance used routinely to measure GFR
- Completely filtered, but secreted in small quantity
- Inverse relationship between GFR & plasma creatinine



Sample Problem

In a 24hr period, 1.44 L of urine is collected from a man receiving an infusion of inulin.

In his urine, the [inulin] is 150mg/ml, and [Na+] is 200 mEq/L.

In his plasma, the [inulin] is 1mg/mL, and the [Na+] is 140mEq/L

What is the clearance ratio for Na+, and what is the significance of its value?

Glucose & urea clearance

- Renal clearance of glucose=zero
- Filtered, completely absorbed, no glucose in urine
- $[U]_g \times V_{min} = zero$
- Urea clearance = 60 ml/min, urea filtered, partially reabsorbed

Inulin clearance vs. clearance of other substance (S)

- C_x = inulin clearance → Substance x is filtered but not absorbed or secreted
- C_y < inulin clearance → Substance y is filtered and partially absorbed
- C_z > inulin clearance → Substance z is filtered and secreted

Summary

1. Renal blood flow
2. Calculation of renal blood flow
3. Autoregulation
   - Myogenic
   - Hormonal regulation (tubuloglomerular & renin-angiotensin)
   - Autonomic regulation
4. Clearance
   1. Inulin
   2. Creatinine
   3. Glucose $ urea