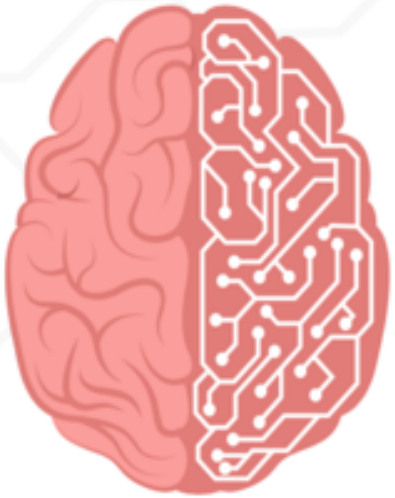

Physiology - GUS

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Heba Al Tahat

Corrected By

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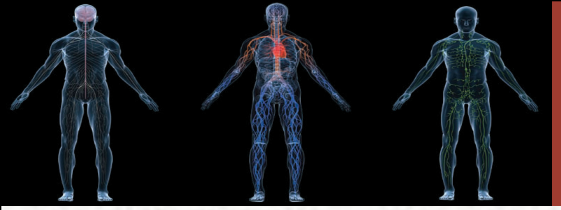
Physio 6



Regulation of Tubular Reabsorption

- Glomerulotubular Balance
- Peritubular Physical Forces
- Hormones
  - aldosterone
  - angiotensin II
  - antidiuretic hormone (ADH)
  - natriuretic hormones (ANF)
  - parathyroid hormone
- Sympathetic Nervous System
- Arterial Pressure (pressure natriuresis)
- Osmotic factors

- As we said before, the substances that are absorbed from the tubules go first into the interstitium then to the capillaries, and the movement of these substances is called the bulk flow.
- This bulk flow (reabsorption) depends on several factors (mechanical or physical forces) that govern the reabsorption of substances towards the blood or plasma.

- Glomerular tubular feedback is very important in the control of the balance between reabsorption and filtration. This feedback means that the higher tubular load that resulted from higher filtration (GFR increased, imperfect renal autoregulation), there will also be feedback correction away from the hormone and nervous system correction where there is matching or compensation by increasing reabsorption

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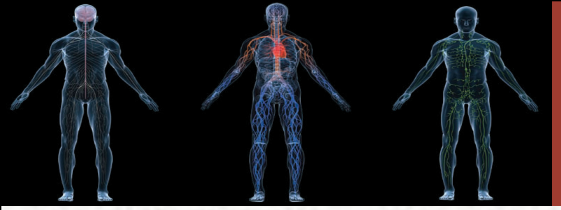
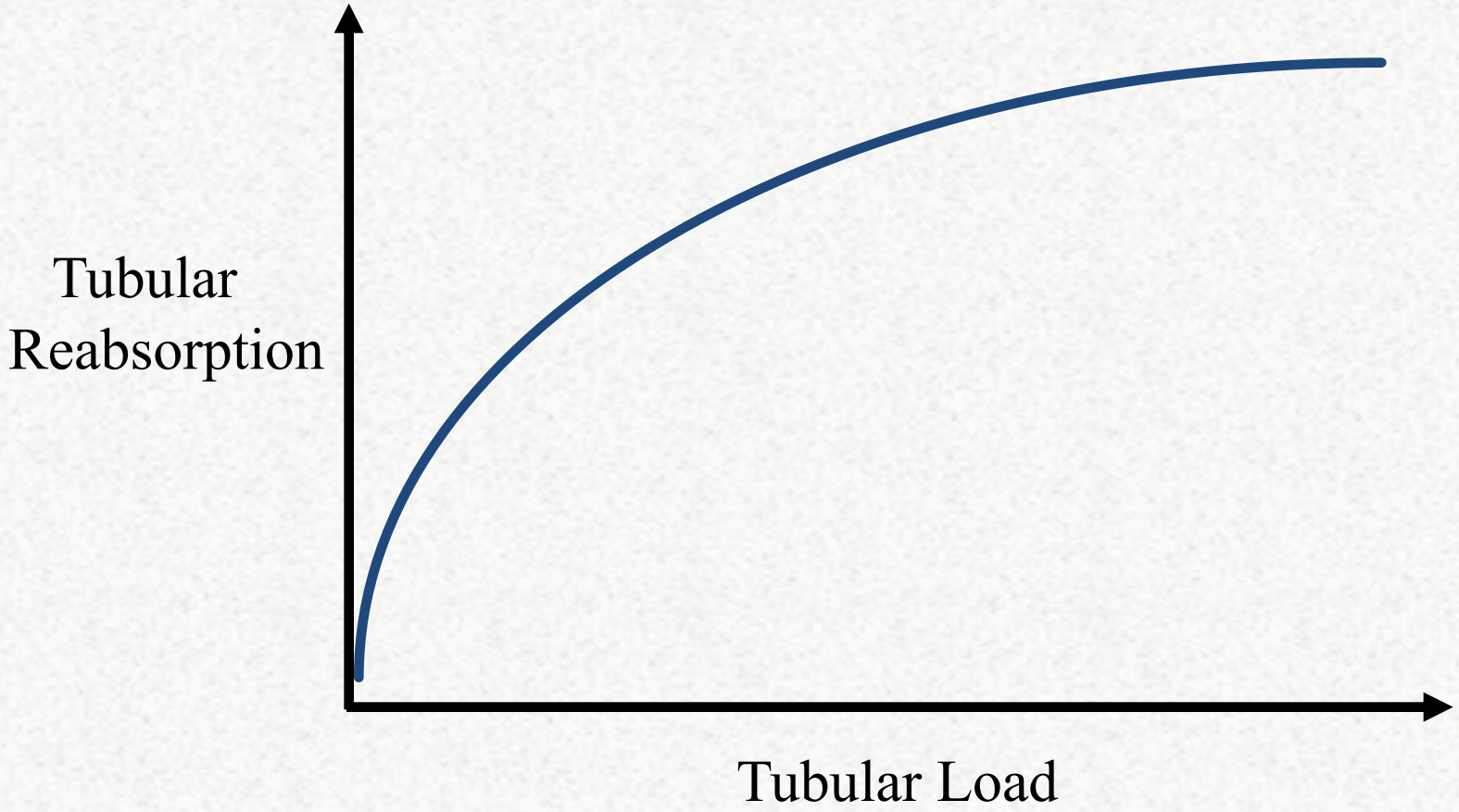


Glomerulotubular Balance



- We can see in this figure, that when the tubular load, which is the amount of filtered fluid or electrolytes, then the flow rate increases, then the tubular reabsorption increases, but up to a limit, because then there is some kind of plateau.
- This is in attempt for compensation

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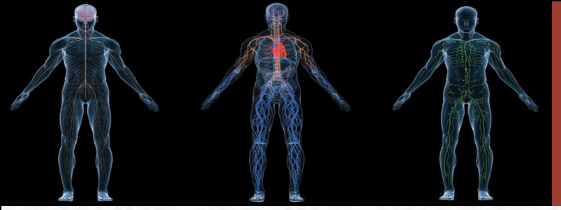

Importance of Glomerulotubular Balance in Minimizing Changes in Urine Volume

GFR	Reabsorption	Urine	% Reabsorption Volume
no glomerulotubular balance			
125	124	1.0	99.2
150	124	26.0	82.7
“perfect” glomerulotubular balance			
150	148.8	1.2	99.2

- In perfect glomerulotubular balance, there is an increase in reabsorption to make sure that the reabsorption percentage stays constant

- In a normal situation, the GFR is 125ml/min, and normal reabsorption is 124ml/min and so the urine flow rate is 1 ml/min. the ratio of reabsorption is 99.2%.
- If there was no glomerulotubular balance accompanied with increased GFR (error in autoregulation. Since there is no glomerulotubular balance then the reabsorption stays the same (124ml/min) and the urine flow is increased to 26 ml/min, which is 26 times more than normal (the amount of excreted urine could reach 30 liters instead of 1).

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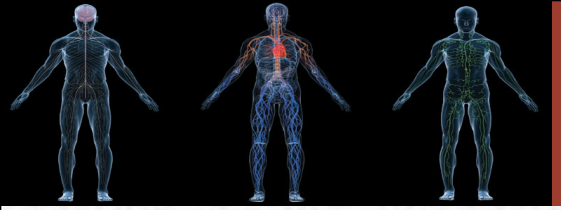
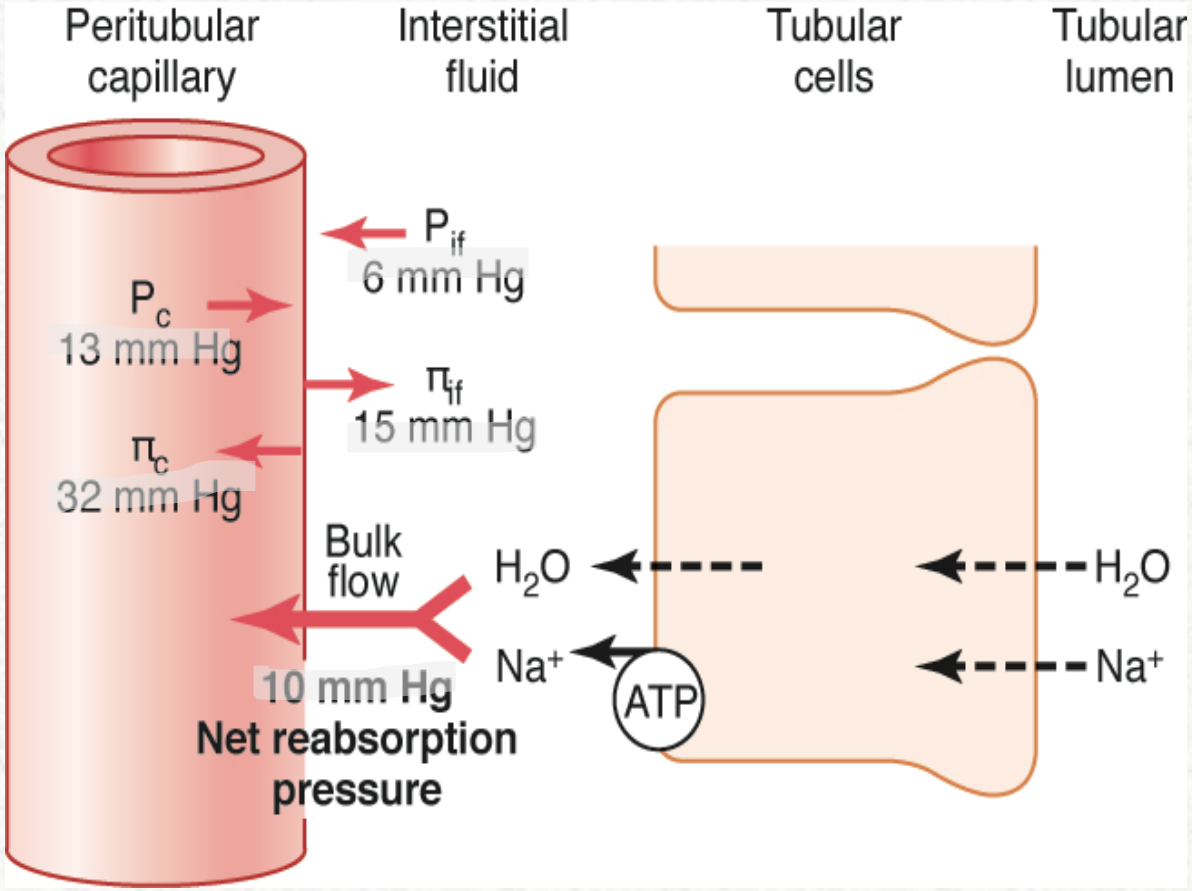


Peritubular capillary reabsorption

Figure 27-15



The most perfect condition is when there is a slight increase of the GFR (not excessive, since it is fixed by the renal autoregulation) and then there is also compensation by the glomerulotubular feedback in order to increase reabsorption, in order to maintain a balance and the urine volume remains within normal range so that there is no excess loss of fluids and electrolytes.

What are the forces that govern the reabsorption to the peritubular capillaries.

1. Peritubular hydrostatic pressure (Pc)
2. Peritubular oncotic pressure (πc)
3. Interstitial hydrostatic pressure (Pif)
4. Interstitial oncotic pressure (πif)

The sum of the hydrostatic pressures is 7mmHg towards the interstitium, while the sum of the oncotic pressures is 17mmHg towards the capillaries, so the net reabsorption pressure is 10mmg towards the peritubular capillary. This is the driving force of reabsorption.

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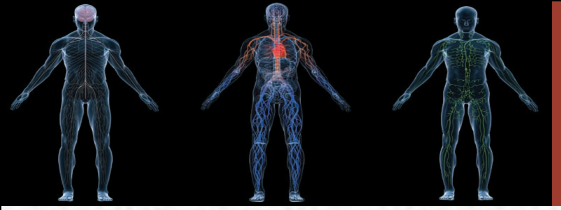

If there was an error in the pressures, for example a decrease in the peritubular oncotic pressure then this would lead to the loss of the driving force of reabsorption. The fluid would start accumulating inside the interstitium instead of going into the capillaries.
BUT this fluid will not stay in the interstitial fluid instead it will leak back into the tubular lumen through tight junctions (especially in the proximal convoluted tubule). This causes an increase in hydrostatic pressure and dilution of the urine.

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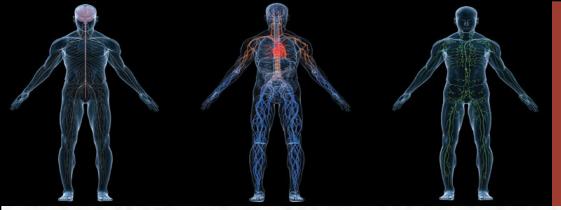


Calculation of Tubular Reabsorption

(when Excret s < Filt s)

Reabsorption = Filtration -Excretion

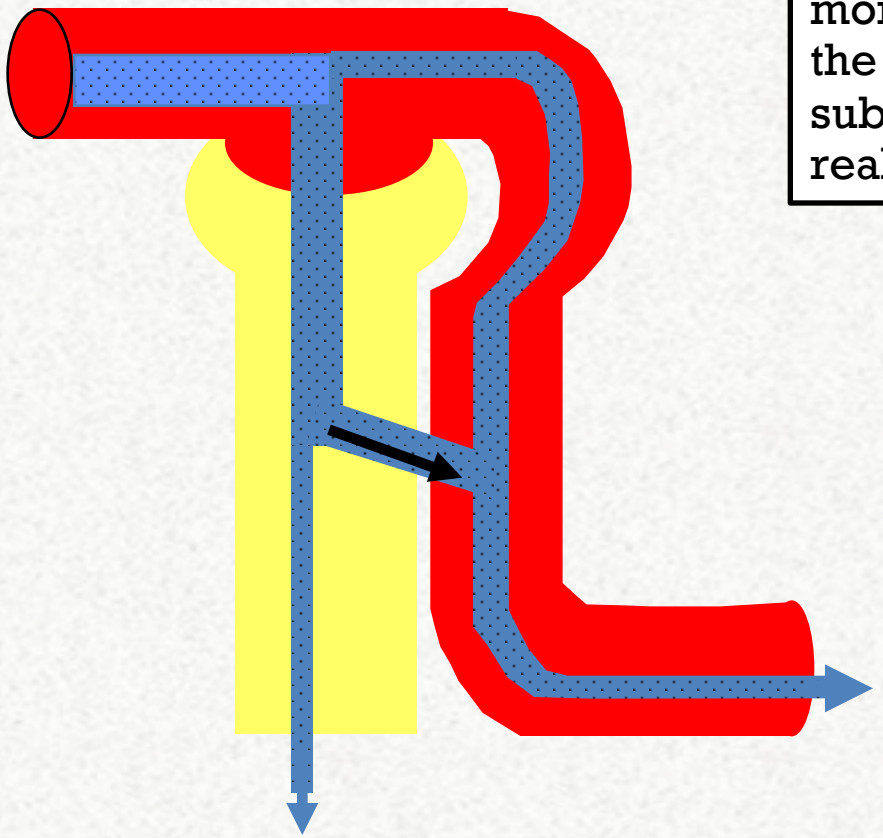
Filt s = GFR x Ps

(Ps = Plasma conc of s)

Excret s = Us x V

Us = Urine conc of s

V = urine flow rate



If the amount of filtered substance is more than the amount secreted in the urine, then this means that the substance is reabsorbed. (net reabsorption)

Watch 21:00-23:45 For explanation of equations

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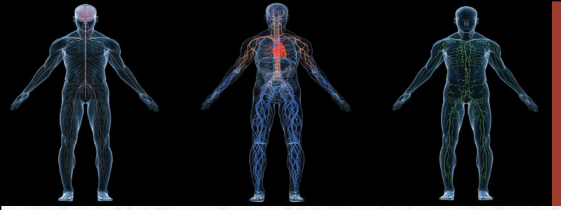


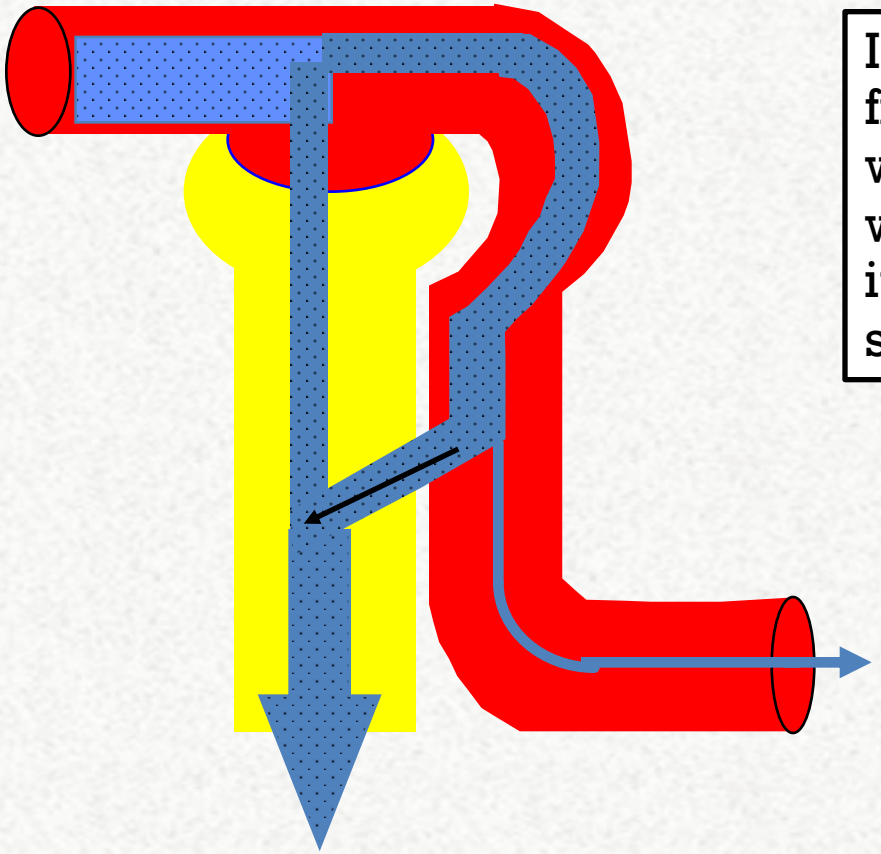
Calculation of Tubular Secretion

(when Excret s > Filt s)

Secretion = Excretion - Filtration

Filt s = GFR x Ps

Excret s = Us x V



If the excretion is more than the filtration, then the substance was secreted from the tubules which caused the increase in its concentration. (net secretion)

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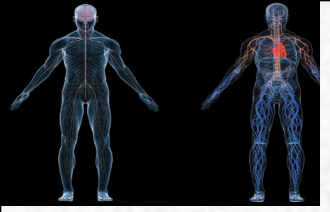

Example: Given the following data, calculate the rate of Na^+ filtration, excretion, reabsorption, and secretion

25:00-27:00

GFR =100 ml/min (0.1 L/min)

P_{Na} = 140 mEq/L

urine flow = 1 ml/min (.001 L/min)

urine Na conc = 100 mEq/L

Filtration Na = GFR x P_{Na}

= 0.1 L/min x 140 mEq/L = 14 mEq/min

Excretion Na = Urine flow rate x Urine Na conc

=.001 L/min x 100 mEq/L

= 0.1 mEq/min

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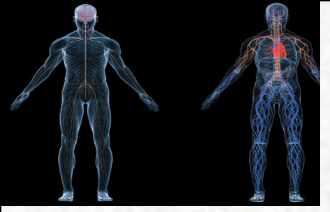

Example: Given the following data, calculate the rate of Na^+ filtration, excretion, reabsorption, and secretion

GFR =100 ml/min;
P_{Na} = 140 mEq/L
urine flow = 1 ml/min;
urine Na conc = 100 mEq/L

Filtration Na = 0.1 L/min x 140 mEq/L = 14 mEq/min
Excretion Na = .001 L/min x 100 mEq/L = 0.1 mEq/min
Reabsorption Na = Filtration Na - Excretion Na

Reabs Na = 14.0 - 0.1 = 13.9 mEq/min

Secretion Na = There is no net secretion of Na since Excret Na < Filt Na

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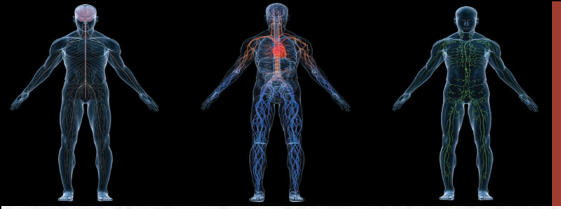

Transport Maximum

Some substances have a maximum rate of tubular transport due to saturation of carriers, limited ATP, etc

- Transport Maximum: Once the transport maximum is reached for all nephrons, further increases in tubular load are not reabsorbed and are excreted.

- Threshold is the tubular load at which transport maximum is exceeded in some nephrons. This is not exactly the same as the transport maximum of the whole kidney because some nephrons have lower transport max's than others.

- Examples: glucose, amino acids, phosphate, sulphate

Glucose reabsorption is controlled by the transport maximum. That means there is a certain amount if glucose that the tubules can transport, so if the concentration of glucose in the tubule becomes more than the transport maximum then this glucose cannot be reabsorbed and some of it will be excreted in the urine

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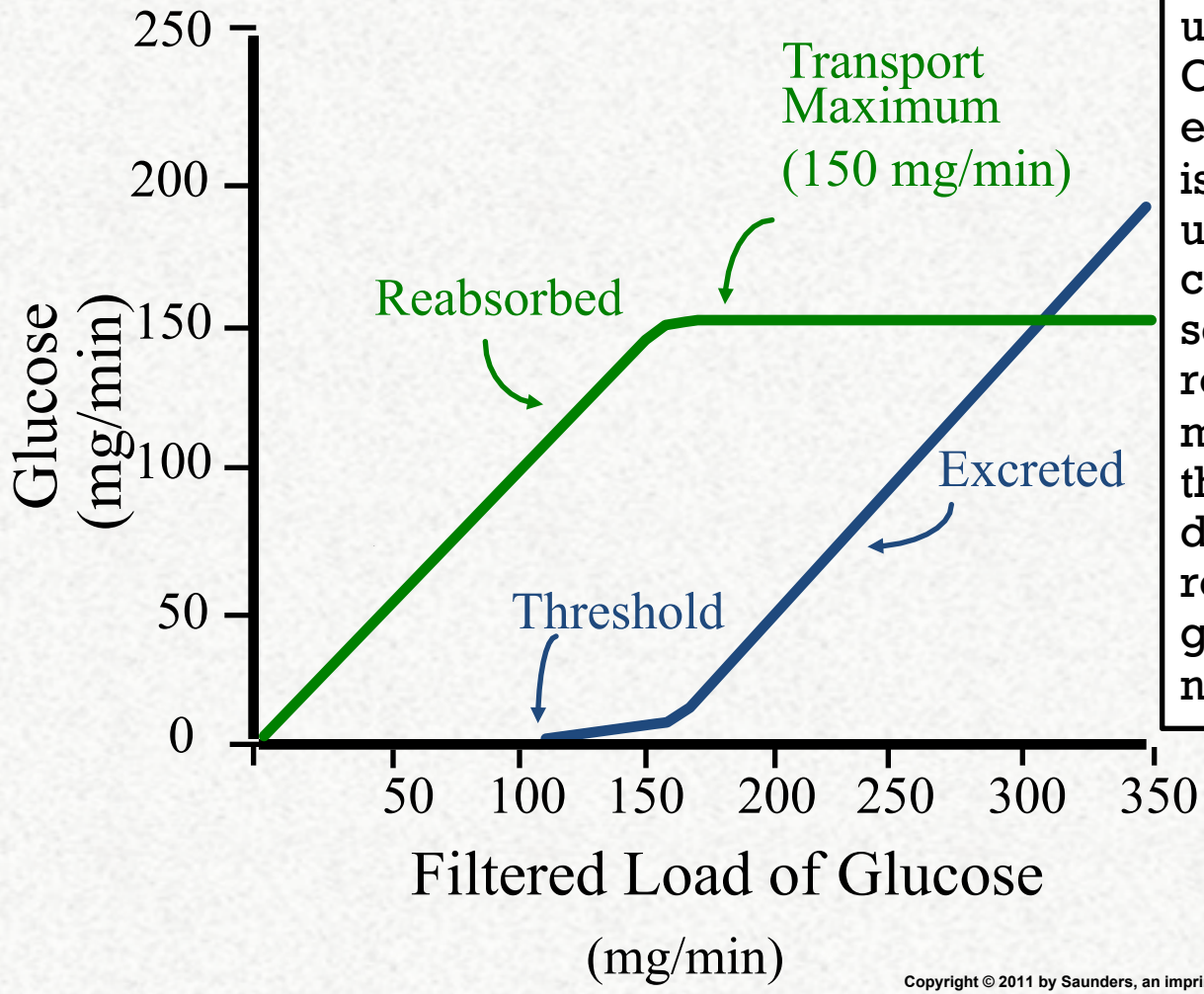
A uninephrectomized patient with uncontrolled diabetes has a GFR of 90 ml/min, a plasma glucose of 200 mg% (2mg/ml), and a transport max (Tm) shown in the figure. What is the glucose excretion for this patient?

1. 0 mg/min
2. 30 mg/min
3. 60 mg/min
4. 90 mg/min
5. 120 mg/min



If this was true then it would mean that when the glucose concentration reaches 150mg/min then the glucose would start appearing in the urine, but this is not true.
On this graph you can see that even before 150mg/min, there is excretion of glucose in the urine. The threshold is the concentration at which we can see glucose in the blood before reaching the transport maximum.
this occurs because of the different efficiency of reabsorption and affinity to glucose in the different nephrons in one kidney.

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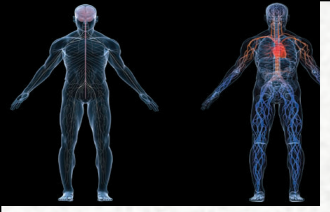


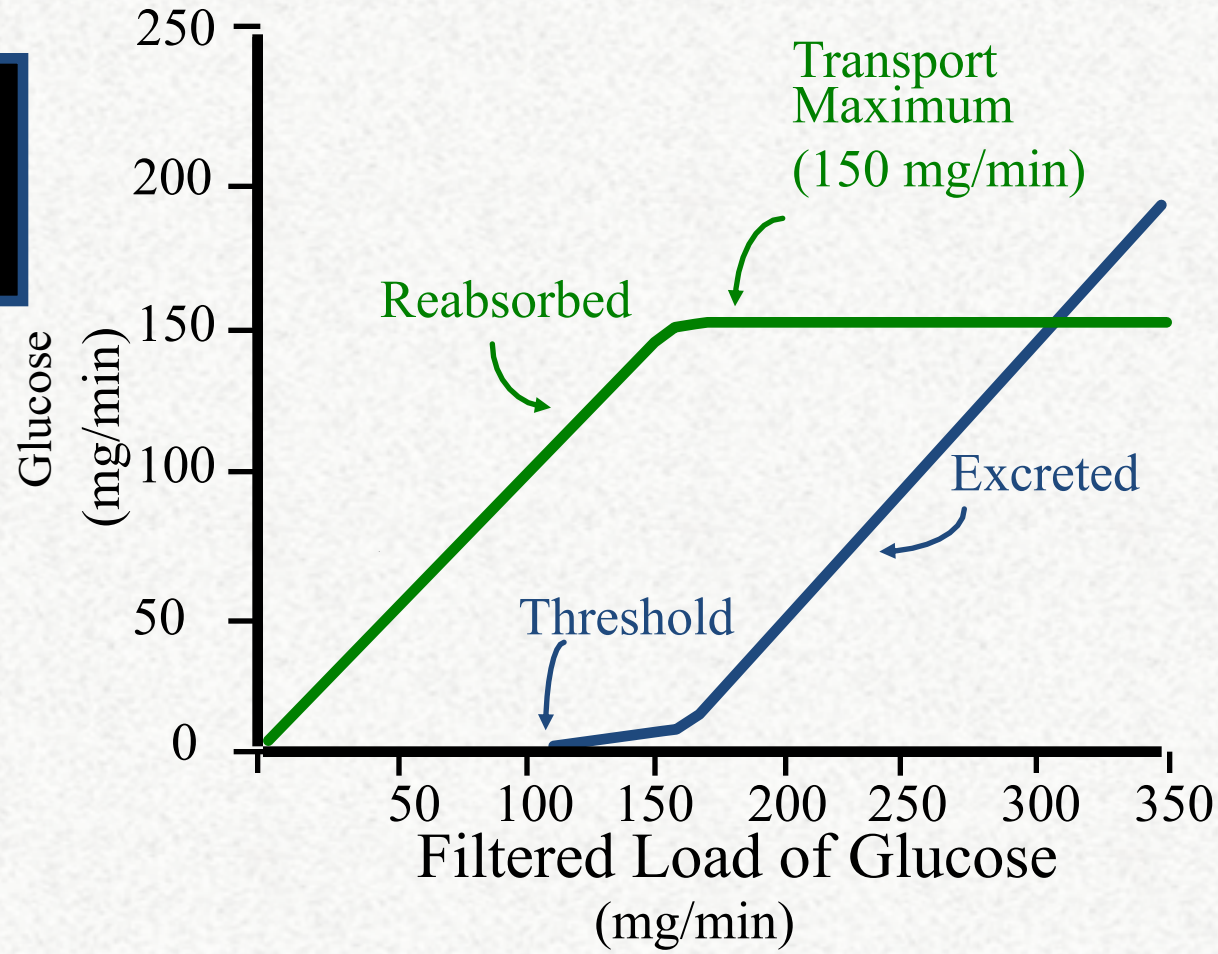
Answer: Filt $_{Glu}$ = (GFR x P_{Glu}) = (90 x 2) = 180 mg/min

Reabs $_{Glu}$ = T_{max} = 150 mg/min

Excret $_{Glu}$ = 30 mg/min

GFR = 90 ml/min
P_{Glu} = 2 mg/ml
T_{max} = 150 mg/min

a. 0 mg/min
b. 30 mg/min
c. 60 mg/min
d. 90 mg/min
e. 120 mg/min



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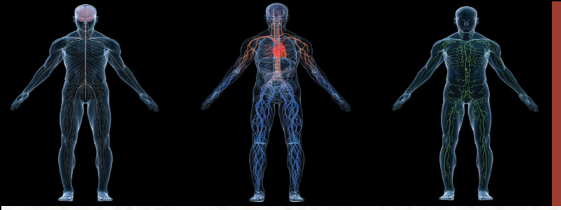

Peritubular Capillary Reabsorption

Reabs = Net Reabs Pressure (NRP) x K_f

= (10 mmHg) x (12.4 ml/min/mmHg)

We just calculated it by summation of hydrostatic and oncotic pressures

A constant that doesn't change except in pathologic conditions

Reabs = 124 ml/min

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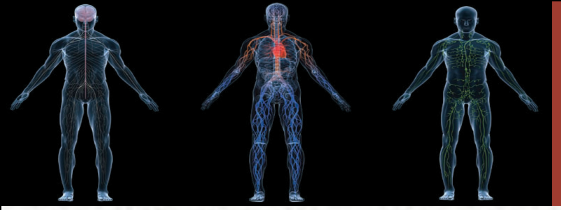

Determinants of Peritubular Capillary Reabsorption

↑ K_f → ↑ Reabsorption

↑ Pc → ↓ Reabsorption

↑ Πc → ↑ Reabsorption

The coefficient is usually constant, if the nephrons and kidneys are functioning properly and there is no pathology, BUT if the coefficient did increase then this would increase reabsorption

If the peritubular capillary hydrostatic pressure increases then the reabsorption would decrease, because they are inversely proportionate and would decrease the net force favoring reabsorption

If the oncotic pressure in peritubular capillaries increases, then this would increase reabsorption (increases the net forces favoring reabsorption

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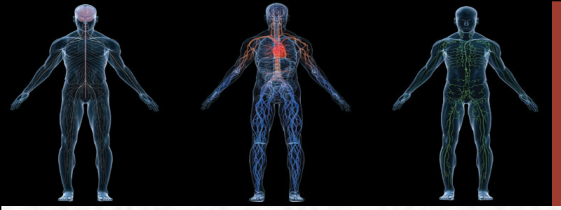
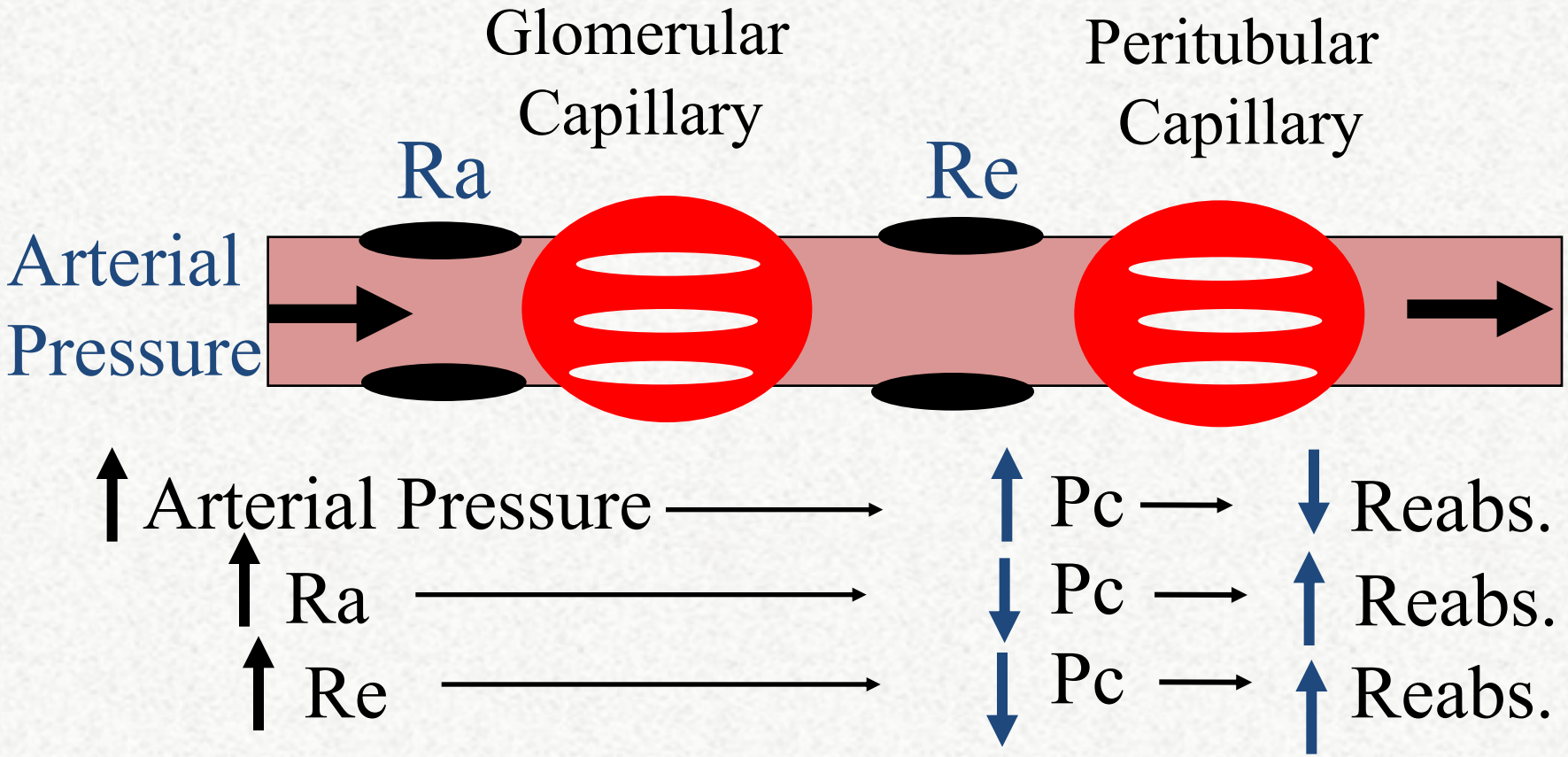


Determinants of Peritubular Capillary Hydrostatic Pressure

38:20



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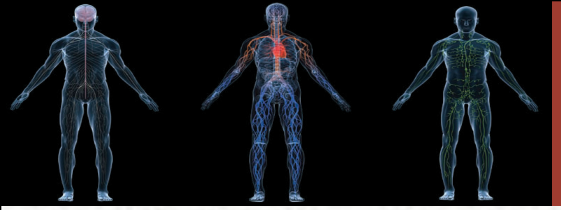

The GFR increases when the glomerular hydrostatic pressure increases, and this decreases the oncotic pressure.
But with reabsorption, it decreases if the hydrostatic pressure increases, and increases if the oncotic pressure increases.

If there was constriction of the afferent arterioles, then glomerular hydrostatic pressure decreases and the renal plasma flow also decreases, then this also decreases the hydrostatic pressure in the peritubular capillaries and this increases the reabsorption.

If there was constriction of the efferent arterioles, this increases the glomerular hydrostatic pressure (imagine it is a balloon and you constricted its opening), but the renal plasma flow decreases, this means that the GFR increases.
The peritubular hydrostatic pressure decreases and this causes increase in the reabsorption.
And vice versa

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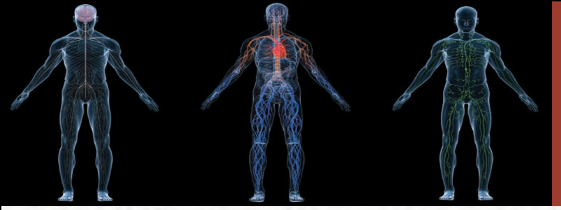

Determinants of Peritubular Capillary Colloid OsmoticPressure

↑ Πc ⟶ ↑ Reabsorption

↑ Plasm. Prot. ⟶ ↑ Πa ⟶ ↑ Πc

↑ Filt. Fract. ⟶ ↑ Πc

Filt. Fract. = GFR / RPF

When the oncotic pressure increases, the GFR decreases, but the reabsorption increases. This depends on the filtration fraction. It is the ratio of the filtered fluid/the renal plasma flow and it is usually 20%. The higher the filtration fraction the more the oncotic pressure.

If the filtration fraction increased, then the reabsorption increases because the oncotic pressure increases, and vice versa. We can say this in the terms of GFR (which represents what actually happens in the body), so if the GFR increases (in turn increases the filtration fraction) then reabsorption increases.

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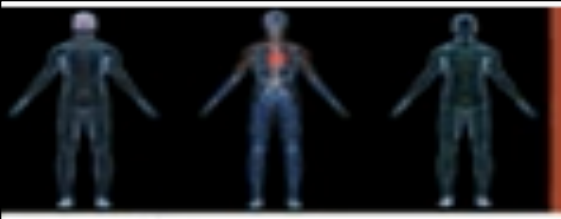

Factors That Can Influence Peritubular Capillary Reabsorption

48:20- the end of the lecture

↑ K_f → Reabsorption

↑ Pc → Reabsorption

↓ Ra → Pc (Reabs)

↓ Re → Pc (Reabs)

↑ Art. Press → Pc (Reabs)

↑ Πc → Reabsorption

↑ Πa → Πc

↑ Filt. Fract. → Πc

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