Human Physiology

Lecture 11 – Wednesday 16/3/2016

"Glomerular Filtration & Tubular Reabsorption" with

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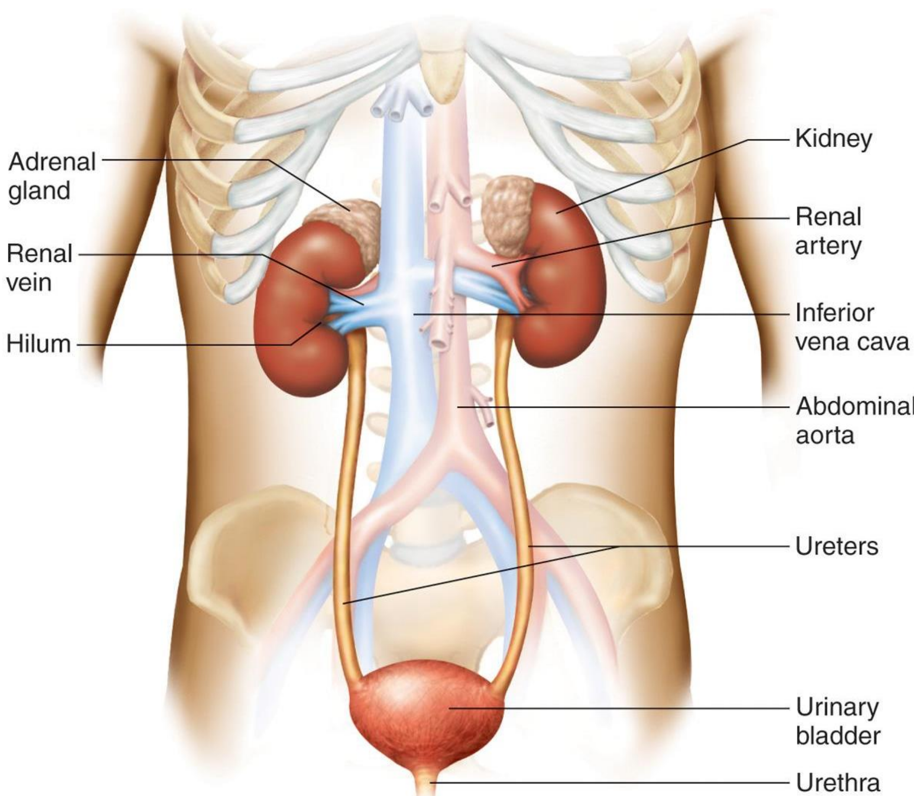


By Haytham Otoom

PSU

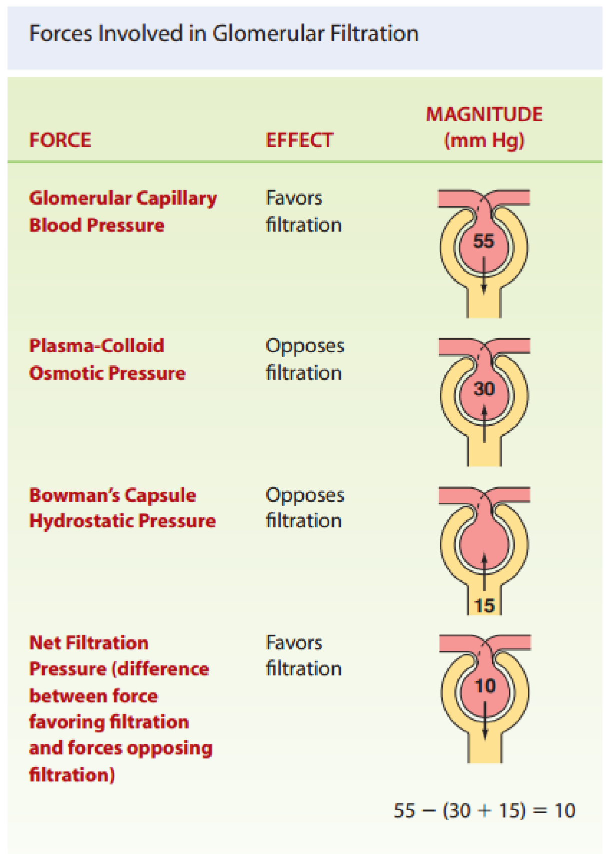
Note: (B) means concept coming from the book, which was not included in the lecture.

Reminder: Blood is filtered by pressure. **Glomerular filtration:**

- All the plasma is filtered except the proteins. In this first step, we call the fluid filtrate & has the same concentration as blood plasma (except proteins). Only 20% of the plasma that enters the glomerulus is filtrated (by pressure). The remaining 80% are not filtrated & continue to circulate around the body. Pressure (ضغط) is the driving force of glomerular filtration; it causes part of the plasma to move into the glomerulus.

Forces that contribute to Glomerular Filtration

- **Capillary pressure:** Normally, in other capillaries the pressure is around 25 mmHg, but in the glomerulus the diameter of efferent arteriole (carries blood away) is smaller than the diameter of the afferent arteriole (carries blood to the glomerulus). This difference in diameter causes an increase in pressure (due to the resistance by the efferent arterioles) – 55mmHg.
  Capillary pressure is the only force that *favors* (يفضل أو يحفز) filtration.



- **Osmotic pressure**: All of the plasma is filtered except the proteins, which causes a high concentration of the proteins in the glomerular capillaries but not in Bowman's capsule. On the other hand, H2O is found more in Bowman's capsule & so it starts to move to the glomerular capillaries by osmosis. This movement *opposes* filtration, and is around 30 mmHg.
- **Hydrostatic pressure**: The pressure exerted by the fluid in the beginning of the tubule, and is around 15 mmHg.

- **Net filtration pressure**: The result of all pressures -> (favors – opposing) = (55 – (30+15)). NFP gives us urine, and is equal to 10 mmHg (under normal conditions). An increase in NFP leads to an increase in the volume of urine produced.
- As we can see, the major force or pressure is blood (capillary) pressure. This is why someone with hypertension (high blood pressure) has higher urine volume.

Effect of vasoconstriction on Glomerular Filtration Rate

- Vasoconstriction is the contraction of the muscular wall of blood vessels (تضيق الاوعية) which results in a decrease in blood flow.
- Reminder: The afferent arteriole brings blood to the glomerulus, and the efferent carries blood away from it.
- So vasoconstriction of
    - Afferent arteriole: causes a decrease in blood flow to the glomerulus, which results in less plasma being filtrated (so a smaller GFR)
    - Efferent arteriole: causes a decrease in blood flow *out* of the glomerulus, which results in an increase in GFR.

Tubular reabsorption

Reminder:

- Tubular reabsorption is the returning or reabsorbing of some of the filtrate // the body takes back useful substances. These re-absorbed substances are not excreted by urine, they are taken back by the capillaries to the vein system. It is called selective because not all substances are reabsorbed. Of the 180 liters formed, about 178.5 liters are reabsorbed. The remaining 1.5 liters leave the body as urine (so the average urine volume is 1.5 liters).

Where & how much reabsorption takes place?

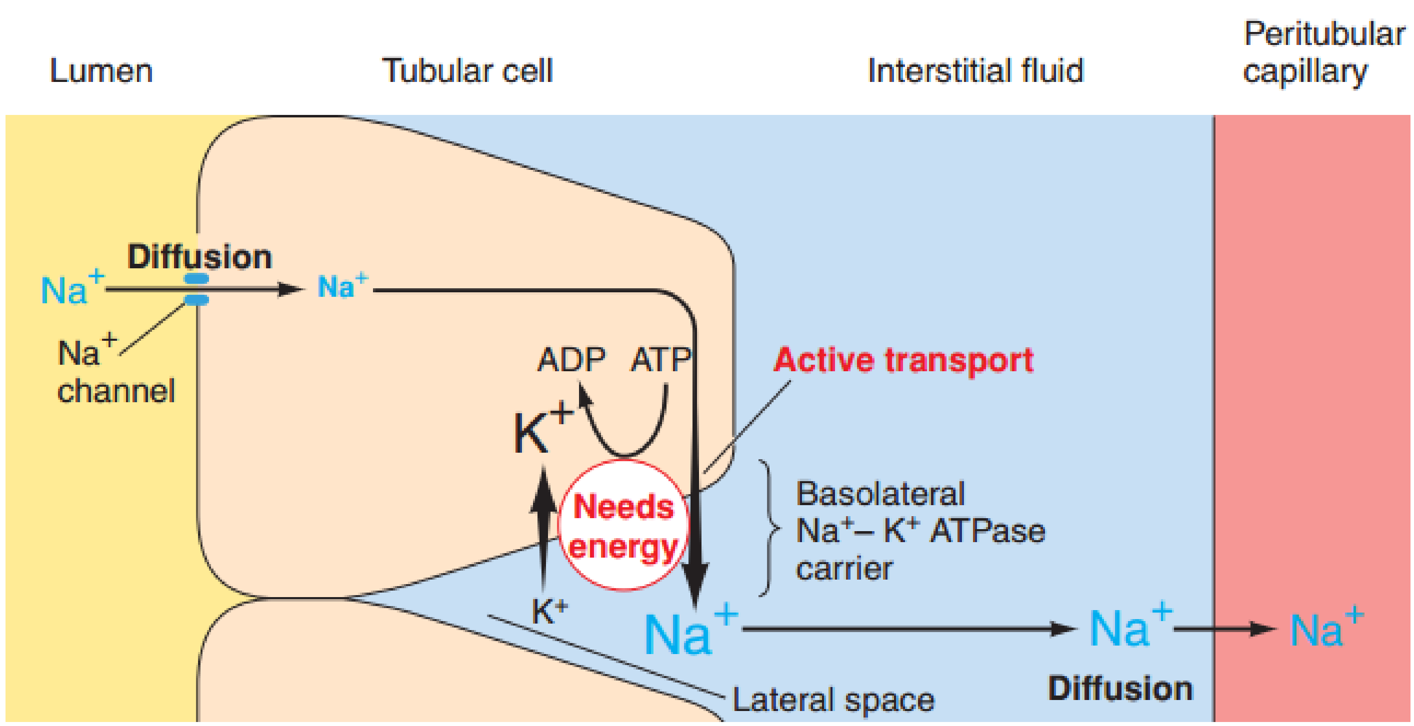
- Reabsorption takes place in -> proximal tubule, loop of Henle & distal tubule.
    - Proximal tubule:
        - Glucose & amino acids are 100% reabsorbed here.
        - **Na^+ & H_2O are 66% reabsorbed here (VERY IMPORTANT)**
        - Urea is 50% reabsorbed here.
        - Remember: Creatinine has 0% reabsorption.

- Loop of Henle:
  - 25% of the remaining Na^+ is reabsorbed here.
- Distal tubule:
  - The last 8% of Na^+ is reabsorbed here.

Stages of transport of substances in the kidney.

- The sequence of stages for substance transport is called **transepithelial transport**, and it takes place in 5 steps or barriers.
- Reminder regarding transport:
  - The movement of water molecules from higher to lower concentration is called osmosis.
  - The movement of substances (example: Sodium ions) from higher to lower concentration is called diffusion, and is a form of passive transport [meaning it does not require energy]
  - However, if the substance moves from lower to higher concentration it is called active transport because this movement is against the concentration (low to high) – and this requires ATP.

So, let's study the reabsorption of Na^+ ions.



- (1) Na^+ moves into the cell by facilitated diffusion, does not require energy as it moves from higher concentration to lower (ECF to ICF, Na^+ is higher in ECF).
- (2) Na^+ moves from the cell to interstitial (tissue) fluid, and this requires energy so it is called active transport [Na^+ moves from low/ICF to high/ECF]
- (3) Na^+ moves from the interstitial fluid to the capillaries by diffusion.
- The entire process is described as active => because one of the steps required energy.

- Glucose & amino acids are actively transported using energy from Na^+ transport, and this is known as **secondary active transport**.
- The reabsorption of Sodium ions is very important… 80% of the total energy spent by the kidney is on the transport of the Sodium ions.
  - Proximal tubule: 67% of it is reabsorbed here.
    - The reabsorption of Na^+ ions here is very important as it leads to reabsorption of glucose and amino acids by secondary active transport.
  - Loop of Henle: 25% of it is reabsorbed here.
    - The reabsorption of Na^+ ions happens throughout the tubule except in the descending limb (الجزء النازل لتحت) of the loop of Henle.
    - The reabsorption of Na^+ ions here is important as it controls the amount of urine produced (depending on the body's need for water)
  - Distal/collecting tubules: 8% of it is reabsorbed here.
    - The reabsorption of Na^+ ions here is subject to hormonal (aldosterone hormone) control. This is useful because it can be controlled to regulate ECF volume, which is also important in controlling blood pressure.
    - Without the aldosterone hormone, there will only be partial (جزئي) reabsorption of Na^+.

Note: The material included here is from the lecture & from the book [Chapter 13, pages 411 to 417]