☑ Sheet ○ Slide ○ Handout

Number

5

Subject

Na Reabsorption and osmolarity changes

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بسم الله الرحمن الرحيم

- **The sheet was written according to section 1 recording with different arrangement.**

Water Reabsorption

- The reabsorption of water in different parts of the uriniferous:
  - 65% of water >> reabsorbed in the proximal tubules.
  - 15% of water >> reabsorbed in the descending tubules of the loop of Henle.
  - 0% of water >> reabsorbed in the ascending tubules of the loop of Henle.
  - 10% of water >> reabsorbed in the distal tubules.
  - 9.3% of water >> reabsorbed in the collecting ducts.
  - 0.7 % of water is excreted.
- Although the proportion of the collecting duct in the reabsorption is small compared with that in the proximal tubule for example but **it's the most important proportion because it's under the control.**

Sodium Reabsorption

- Why do we care of studying sodium?!
  1. It's important in the **reabsorption of glucose and amino acids** in the proximal tubules through the co-transport secondary active transport.
  2. It's important in **Acid- Base balance** through the counter transport secondary active transport with Hydrogen in the proximal tubules. Also, important in the **potassium homeostasis** because of the counter transport secondary active transport.
  3. Determine the **extracellular fluid volume**; if its concentration increase then the cell would be swelling, if it's low in concentration then a volume contraction occur.
  4. Determine the **excitability of the cell;** a lot of cells are depolarized through the influx of sodium.

5. It's very important in the **concentrating ability of the kidney**; that makes it a very good target of a lot of diuretics. a lot of diuretics inhibit the reabsorption of sodium then increase the excretion of sodium and water.

- The reabsorption of sodium through the uriniferous:
    1. 65% >> in the proximal tubules.
    2. 0% >> in the descending tubule in the loop of Henle.
    3. 25% >> in the ascending tubule in the loop of Henle.
    4. 5% >> distal tubule.
    5. 4.3% >> collecting duct
- the reabsorption of sodium in both the distal tubules and the collecting ducts is **the most important due to the fact of being under the control -- increase the reabsorption by the ADH and decrease the reabsorption by the ANT.**

- some calculations regard to sodium homeostasis :
    - the filter load of Na = GFR* [Na]
      = 180 L/day * 140mE/L
      = 25200mEq/ day

    - How much is excreted? 150 mEq/day {150 mM}
      then proportion of excretion equals 150/25200 *100 % = .59 %

    - How much is reabsorbed?!
        - Reabsorbed sodium = the filter load – the excreted sodium
          = 25200 -150 = 25050mEq/day
        - The proportion of reabsorbed = 100 -.59 = 99.41 %.

    - The sodium intake should equal the sodium output to get a balance, whenever the intake is more than the output then we have + balance, if the intake is less than the output then – balance.

    - Sodium Homeostasis:
      Sodium intake:155 mM
      Sodium output: the sodium is removed mainly by the kidney but it could be removed by other ways like the sweating and GI secretions. {{the sodium removed by kidney per day: 150 mM}}.

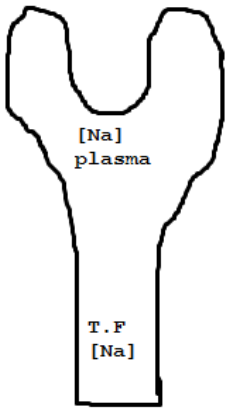
GFR of Na = 180L/day

mEq: milli equivalent

mM = mEq/ day

- The question Now is How could the scientists determine the proportion of reabsorption in each segment?!

  - Let's take the proximal tubules as example to discuss that!
    If we take two samples the **1st one from the bowman's space** and **the 2nd one from the end of proximal tubules** and analyze the concentration of **sodium** in both samples we would find that they have **same** concentration, How Come?!
    the sodium and water are reabsorbed in the **same** proportion through the proximal tubules then the concentration of the sodium still the same!



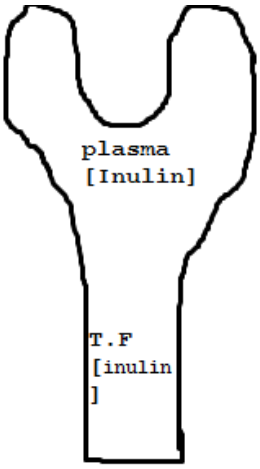
  - Then what we do is measure the proportion of water reabsorption to know the proportion of sodium reabsorption in the proximal tubules, how can we do that?!

    Inject the patient with **inulin** then taking two samples 1st in the bowman's space and the 2nd at the end of the proximal tubule.

    After the analysis of these two samples let's assume that

    [Inulin in the bowman's space] / [inulin at the end of proximal tubule] = 2

    So, what ?!
    this means that 50% of water is reabsorbed bcz as we know from previous **lectures Inulin is not reabsorbed or secreted**. Because the [Na] in both samples still the **same** then the reabsorption of sodium in the **same proportion of water and in our assumption 50% of sodium is reabsorbed.**



- If [Inulin in the bowman's space] / [inulin at the end of proximal tubule] = 3

  65% of water is reabsorbed and 65% of Na is reabsorbed.

- If [Inulin in the bowman's space] / [inulin at the end of proximal tubule] = 4

  75% of water is reabsorbed and 75% of Na is reabsorbed.

1) **The concentration of sodium and inulin in the bowman's space is the same as that in the plasma L bcz the filtrate is that same as plasma except there are no proteins.**
2) **[Na] in plasma equal 140 mEq/L.**

And so on.

- Now, we will discuss the concept of **Single Nephron GFR { SNGFR } :**
  - Through this technique, we can know how the kidney handle with water, sodium and any substance.
  - There are some assumptions for this technique:
    1) GFR is the same
    2) There is no leaky through the tubule, then we are talking about a free flow.
  - By this technique, we can measure the clearance of substance X across the **proximal tubule for example** {previously when we talked about clearance we meant clearance across the nephron at whole}!
  - Clearance = (T.F[x]/ P[X]) * Flow Rate
    T.F[X]: Concentration of X in the Tubular fluid
    P[.X]: Concentration of X in the Bowman's space as well as plasma.
  - Clearance of the Inulin = (T.F[Inulin] /P[Inulin]) * Flow rate
    The T.F [Inulin] / P [inulin] = 3 as we mention before in the sheet bcz 65% of water is reabsorbed.
    Then clearance of the Inulin= 3* Flow rate.
    The flow rate can be measured by collecting the excreted urine per time.
  - Clearance of the Na = (T.F[Na] /P[Na]) * Flow rate
    The T.F [Na] / P [Na] = 1 as we mention before in the sheet bcz water and sodium are reabsorbed in the proximal tubules in the same proportion.
    Then clearance of the Na = 1* Flow rate.
  - If we compare the clearance of Na with the clearance of inulin, then
    Clearance Na / Clearance Inulin = 1/3 what does this mean?!
    This means that 2/3 of sodium is reabsorbed and only 1/3 of sodium reach this point.
  - if Clearance Na / Clearance Inulin = ½ then 50% of sodium is reabsorbed and 50% reach this point.
  - This double ratio **gives the fraction of the filtered load remaining at any point along the nephron.**
  - The clearance of inulin shouldn't be less than 1 why?! Bcz the water isn't secreted it's only reabsorbed or not reabsorbed.
  - Again, to know how any segment of the kidney handle with any substance, we just divide its clearance on the clearance of the inulin.
- If we find that the C**learance of X / clearance of Inulin = 1,** what this means?
  Does it mean that the kidney handle this substance just like the inulin then X is **not secreted nor reabsorbed**?!

this is **not 100% accurate**; this substance may be reabsorbed at point and secreted at another point then they cancel each other's, So What?!

- To know exactly what is happening, we have to take samples from the middle {bcz the distance between the beginning and the end is too much then secretion and reabsorption can co-occur and cancel each other's}, then do the micro puncture technique by **injecting dye to make sure that you're in** then putting a drop of **oil** which would stop flow then we take **two samples** and **divide** them to each other to get the proportion of reabsorption.

- The micro puncture technique: **segmental function of the nephron**, discovered by 1924 by Richard brothers, what makes it difficult that it should be done **in vivo not vitro**. also, it can **isolate the cortical segments only not the medullary ones, too.**

- To study the medullary segments, the scientists find a way through the **pelvis of ureter to reach the kidney and take samples to study them.**

Osmolarity changes:

- As we know we have three compartments:
    1) Intracellular
    2) Intravascular
    3) Intercellular.
        - These three compartments are **different in the concentration of ions** {but in the same compartment, **the concentration of anion = cat ion to get neutral state**}
        - These three compartments are **different in the protein** concentration.
        - With all these differences, they all have the **same osmolarity** (285 milli osmole), which makes the water is **freely filtered** {there are no barriers for water!}
- What does the **isotonic** solution mean ?! if you put RBC in this solution, **then they wouldn't be shrinked or swelling.**
- What does the **iso-osmotic** solution mean?! its osmolarity = **300 milli osmole** just like the **plasma**.
  if the osmolarity **>** 300 milli osmole then it's **hyper** osmotic.
  if the osmolarity **<** 300 milli osmole then it's **hypo** osmotic.

- How many grams of Normal saline we need to get an iso-osmotic solution?!

  Normal Saline is NaCl then the the **molar mass of NaCl** can be calculated for **finding** the atomic **mass** of sodium (23g/L) and the atomic **mass** of chlorine (35.45 g/L) and combining them.
  Molar Mass of Nacl = 58.5 g/L
  NaCl when is put in the solution it's divided into 1 osmole of Na and 1 osmole of Cl, so **2 osmoles.**
  2osmole = **2000 milli osmole,**
  So,
  58.5 g/L of NaCl ⟶ 2000 milli osmole
  X ⟶ 300 milli osmole
  So,
  X=58.5*300 /2000 = **9g/L = 0.9 g/dl = 0.9 % N/S**

- How many grams of dextrose water solution we need to get an iso-osmotic solution?!
  The molar mass of glucose = 180g/L
  The glu in solution remain **1 osmole = 1000 milli osmole**
  180 g/L of Glu ⟶ 1000 milli osmole
  X ⟶ 300 milli osmole
  So,
  X= 180*300/1000 **= 50g/L = 5g/dl = 5% O/W.**

We have to memorize these numbers as our names!

- Now, after we discuss some basics of osmolarity concept let's move up to discuss the changes of osmolarity across the nephron.

  - The **filtrate** in the bowman's space is **iso-osmotic** just like the plasma without proteins.
  - The Tubular Fluid in the proximal tubule is also **iso-osmotic** bcz the salts and water are reabsorbed in the **same** proportion.
  - The membrane is permeable to water but impermeable to salts in **the descending part of the loop of Henle** then tubular fluid equilibrate with the interstium whatever it's; become **hyper -osmotic depending.**

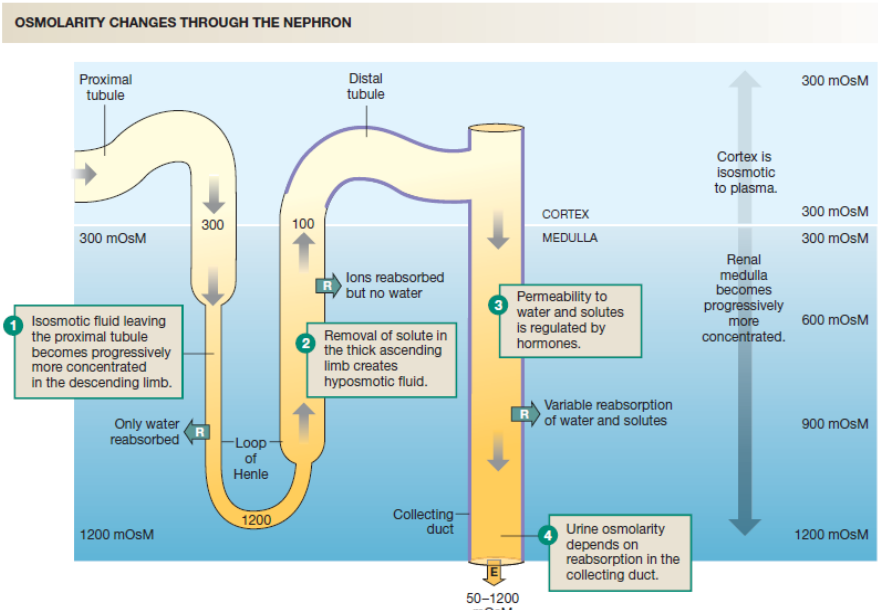
- The tubular fluid in the ascending part of the loop of Henle become hypo-osmotic bcz this membrane is impermeable to water but permeable to salts. {it's the only membrane that is impermeable to water}.
  - ✓ some of you may be confused that we always say that the water follow the sodium and the sodium is a good indicator for the extracellular fluid but that isn't applied here that's what's **called the single effect by which the sodium is reabsorbed and the water isn't then increase the osmolarity in the interstium and decrease it in the tubular fluid.**

- The tubular fluid in the distal tubule become hypo-osmotic (90 milli osmole) bcz this membrane is impermeable to water.
  - The tubular fluid here has two choices:
    1) Conserve water and reabsorb it as going down {that what is happening in the normal situation}
    2) Loss water and not reabsorb it then the urine would be hypo-osmotic.
- The tubular fluid in the collecting duct become hyper-osmotic (1400 milli osmole) how come?!
  - ✓ The scientists spent thousands of years to explain how the kidney produce a concentrated urine, they found that water is **actively reabsorbed then we end up with hyper-osmolar urine.**
  - ✓ These channels under the control of the **ADH**. The membranes of the collecting ducts aren't permeable to water all the time, but under the control of ADH; **ADH** would excite the **formation of these channels** then what inside the tubules **equilibrate** with what is in the interstium {the interstium **is hyper osmotic** as a result of role of the loop of Henle as discussed before}
  - ✓ if these channels are **closed** then what inside is **different** from what is in the interstium.
  - ✓ Diluted urine is easily explained; Na/ K are actively reabsorbed and the water is kept not reabsorbed then the urine is diluted.
  - ✓ As we go down, the urine become more concentrated.

- To have a concentrated urine:
  - ✓ The **interstium** surround the collecting duct is **hyper** osmolar that is achieved by the loop of Henle ((this is a must but is NOT enough)).

- ✓ The **membrane** of the collecting ducts is **permeable** to water, that is under the control of ADH.

- **Hypo volemia, hypotension and hyper-osmolar blood** all stimulate the **hypothalamus** to secret the **ADH** >>> **open** water channels in the collecting ducts >> reabsorption of water >> **concentrated** urine.
- The more we go down >> the more the concentrated tubular fluid.



- NOTE:
  If we take a sample at the **beginning** of the **ascending** tubule of the loop of Henle and a sample at **end** of the **ascending** tubule of the loop of Henle, we would find that the concentration of the **inulin is the same**, so What?!
  The water in this segment isn't reabsorbed!

Sorry for any mistake ☺
Wish you all best of luck ^^
Ayat M.Zghoul