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Renal Physiology L7

- **Clearance**
  - "Clearance" describes the rate at which substances are removed (completely cleared) from the plasma.
    - It is the most important function of the kidney
    - It is a rate, and it differs from substance to another.
      - The clearance also depends on the GFR
  - Renal clearance of a substance is the volume of plasma completely cleared of a substance per min by the kidneys.
- **Clearance Technique**
  - Renal clearance of a substance is the volume of plasma completely cleared of a substance per min.
  - **Cs x Ps = Us x V**
    - Where :
      - Cs = clearance of substance S
      - Ps = plasma conc. of substance S
      - Us = urine conc. of substance S
      - V = urine flow rate

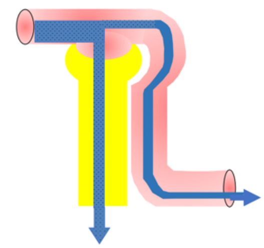
$$C_s = \frac{U_s \times V}{P_s} = \frac{\text{urine excretion rate}}{\text{Plasma conc. s}}$$

- **Clearances of Different Substances**
  - Glucose and albumin have zero clearance since normally it has zero excretion rate
  - Urea has a high clearance rate which makes sense since we want to get rid of urea since it is a waste product
  - Inulin has a clearance rate of 125 ml/min which is the exact same as the GFR (we discussed this in the previous lecture)
  - Creatinine which is an endogenous waste product normally produced has a 140 ml/min clearance rate
    - It can be used as an estimation of GFR
  - PAH has a clearance rate of 600 ml/min which is very close to the renal plasma flow so it can be sued to estimate the renal plasma flow

Substance	Clearance (ml/min)
glucose	0
albumin	0
sodium	0.9
urea	70
inulin	125
creatinine	140
PAH	600

- **Use of Clearance to Measure GFR**
  - For a substance that is freely filtered, but not reabsorbed or secreted (e.g inulin[125], I-iothalamate, creatinine), renal clearance is equal to GFR
    - Not used clinically
  - amount filtered = amount excreted
  - $GFR \times P_{in} = U_{in} \times V$
    - P_{in} = plasma concentration of inulin
    - U_{in} = urine concentration of inulin
    - V = urine flow rate

$$GFR = \frac{U_{in} \times V}{P_{in}}$$



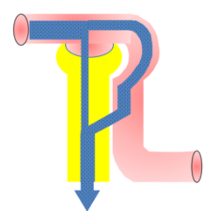
- **Calculate the GFR from the following data:**
  - $P_{inulin} = 1.0$ mg / 100ml
  - $U_{inulin} = 125$ mg/100 ml
  - Urine flow rate = 1.0 ml/min

$$GFR = C_{inulin} = \frac{U_{in} \times V}{P_{in}}$$

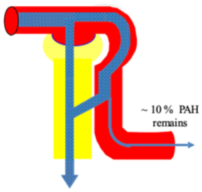
$$GFR = \frac{125 \times 1.0}{1.0} = 125 \text{ ml/min}$$

    - Using inulin to measure GFR is only experimental, because we must have the patient hospitalized then infuse them with a certain amount of inulin, then measure the urinary flow rate and urinary concentration of inulin, as well as the plasma concentration of inulin when it is in a steady state in the plasma.
      - This is not practical and will expose the patient to many risks like renal failure.

- **Use of Clearance to Estimate Renal Plasma Flow**
  - Theoretically, if a substance is completely cleared from the plasma, its clearance rate would equal renal plasma flow
  - Cx = renal plasma flow



- **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



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

  - 1. amount enter kidney =
    - ERPF x P_{PAH}
      - We can replace the clearance with ERPF
  - 2. amount entered ~
    - = amount excreted
  - 3. ERPF x P_{PAH} = U_{PAH} x V
    - ERPF = Clearance PAH
      - The calculated value is not the actual RPF rather, it must be corrected, because not all plasma will be cleared, instead, a part of the PAH will remain in the plasma (about 10%)

- **To calculate actual RPF**
  - one must correct for incomplete extraction of PAH
  - A_{PAH}=1.0
    - 100% is found in the renal artery
  - V_{PAH} = 0.1
    - 10% is what remained in the renal vein

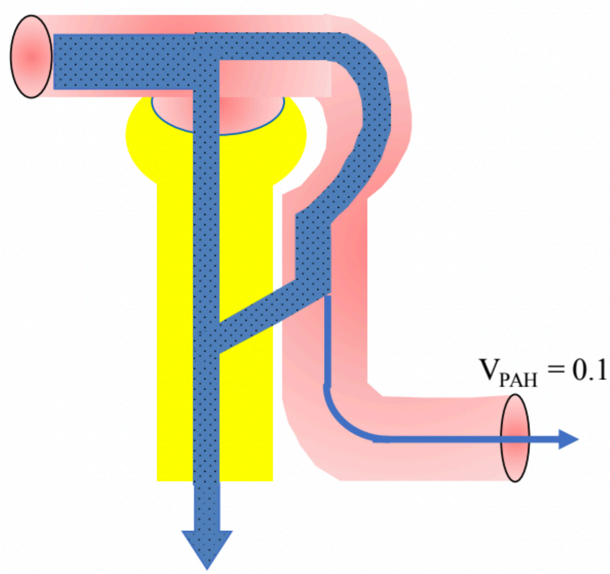
$$E_{PAH} = \frac{A_{PAH} - V_{PAH}}{A_{PAH}}$$

$$= \frac{1.0 - 0.1}{1.0} = 0.9$$

normally, $E_{PAH} = 0.9$

i.e PAH is 90 % extracted

$$RPF = \frac{ERPF}{E_{PAH}}$$



□ Clearances of Different Substances

Substance	Clearance (ml/min
inulin	125
PAH	600
glucose	0
sodium	0.9
urea	70

Clearance of inulin (C_{in}) = GFR

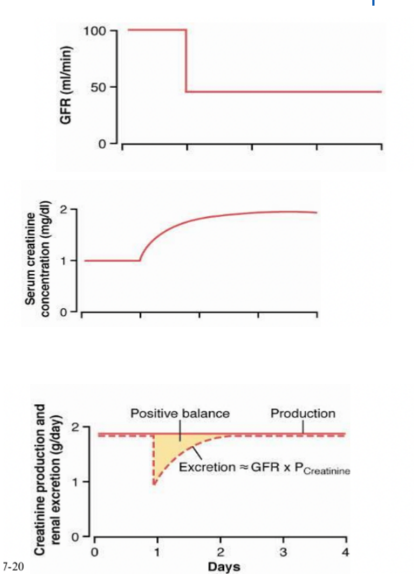
if Cx < Cin : indicates reabsorption of x

if Cx > Cin : indicates secretion of x

Clearance creatinine (C_{creat}) ~ 140 (used to estimate GFR)

Clearance of PAH (C_{pah}) ~ effective renal plasma flow

□ Effect of reducing GFR by 50 % on serum creatinine concentration and creatinine excretion rate



- A patient with reduced GFR as a result of renal disease or loss of nephron this would affect their ıe production, plasma concentration and their excretion
  - As you can see that the GFR here reduced to half and this caused the serum concentration of creatine started to increase then t reaches a plateau
  - If you look at the creatine production , at first when there is a reduction in GFR, the creatine production did not change but the renal excretion reduced transiently then it will increase , this is because we know that the excretion of creatinine equals the GFR x Plasma creatine concentration, and since the GFR was reduced the plasma creatinine concentration will actually increase, increasing the excretion bringing it back to normal so that there is no net effect on the excretion rate