Filtration

We have three types of capillaries in our body:

1) The most common (classical type/systemic capillaries):

Found in most parts of our body .has a filtration at the arterial end and reabsorption at the venous end. 20 L filtered / day, 17 L reabsorbed / day, 3L/day retained by the lymphatics (17+3=20).

2) Found in the GI, only reabsorption.

3) Glomerular capillaries (kidney), only filtration (180 L filtered /day) more than the whole body (systemic capillaries) in approximately 10 times despite its small size relative to whole body.

- **Filtration** means movement of fluids from the glomerular capillaries to Bowman's space per unit time (minute).
- The composition of the ultrafiltrate (the bowman's space fluid) is the same as plasma. The only difference that its protein- free fluid (doesn't contain protein) .So, **ultrafiltrate = plasma – proteins**.
- Filtration is different from diffusion :
  - ✓ [From Yahoo answers**: filtration**- separation of a liquid from the undissolved particles floating in It.
    diffusion- Movement of a fluid from an area of higher concentration to an area of lower concentration.]
  - ✓ **filtration** is a bulk flow governed by starling forces (pressure differences) .الجمل بما حمل
    Diffusion is a 'molecule by molecule' movement governed by concentration gradient or electrochemical gradient (but not pressure)
- Filtration is a flow, and as we know the flow is directly proportional to the driving force (starling forces) and the permeability & is inversely proportional to the resistance (resistance and permeability are opposite to each other).

Written by راية عبدالحميد المجالي

✓ **What are these *starling forces*?**

☒ Two forces **inside** capillaries (intravascular):

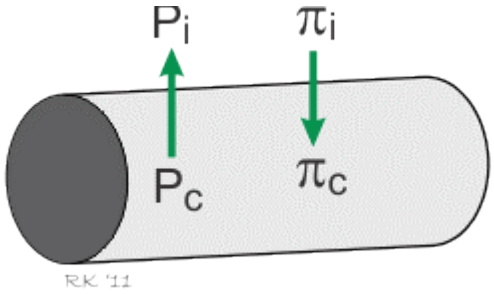
1) Blood hydrostatic pressure in the capillaries **(Pc)** which equals 40mmHg at the arterial end and 20mmHg at the venous end (systemic capillaries) so the average for Pc in the systemic capillaries is 30mmHg

2) **πc** (colloid osmotic pressure due to proteins, mainly Albumin) which equal 28mmHg at the arterial and venous end (same in the both ends of the capillaries)

☒ Two forces **outside** capillaries (Interstitial):

1) Tissue interstitial hydrostatic pressure **(Pi)**

2) **πi** (colloid osmotic pressure)



Note: ***πi* is variable from one tissue to another. It is very high in the liver interstitium because the liver capillaries are very permeable to proteins, However, the kidney (glomerular capillary) is impermeable to proteins (proteins can't be filtered to bowman's space) so we don't have *πi* in kidney as a result we have 3 forces (starling forces) that control GFR:**

1. Glomerular capillary hydrostatic pressure. (Favors filtration)
2. Glomerular capillary colloid osmotic pressure. (Opposes filtration)
3. Capsular hydrostatic pressure. (Opposes filtration)

Why albumin and not globulin is more important in determining the **πc**?

Because it has a small mw (70) this means that if you have 1 g of albumin, and 1 g globulin, you will have more molecules in the 1 g albumin. The small molecule has the same effect in attracting water as the large molecule that's why we don't care about the size of the molecule but about the number, & albumin is more concentrated in the blood (but the number effect which depends on M.W is more important).

**Concentration of proteins in the blood is 6-7 g /dl, [albumin] = 3.5-5.5 (<3.5 hypoalbuminemia (generalized edema),> 5.5 hyperalbuminemia). [Globulin]= 2-4.

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- ✓ Too much filtration is bad; it causes accumulation of fluid in the interstitial space (edema). It may be due to an increase in the driving force (ΔP), or a problem in the permeability (an infection for example that increased the permeability of the capillaries).
- ✓ Too little filtration is bad, because urea, createnine, uric acid are all waste products that will stay in the blood and accumulate.

- **Glomerular filtration rate (GFR):** volume of fluid filtering from the glomerular capillaries to the bowman's space per minute.
- **Filtered load**:
  - ✓ is the amount of a substance filtered per minute
  - ✓ It's affected by two factors: glomerular filtration rate (GFR) & concentration of a substance (when the GFR is constant then the more the concentration in the plasma the more the filtered load – unlimited linear relationship because filtration is passive-)
    - **Filtration fraction = GFR / RPF (~20%)**
    - **Filtered load(X)= GFR* Conc. Of X in plasma**

Measurement of GFR

- **Inulin:**
  - ✓ Small molecule (mw 5000)
  - ✓ 1. freely filtered (its concentration in the ultrafiltrate [bowman's space fluid] same as in plasma)
    2. not reabsorbed
    3. Not secreted (this's how it's different than PAH).
       - ☒ What does this mean?
         Only what's filtered of inulin is going to be excreted since the **excretion = secretion + filtration**, and secretion in this case is ZERO >> **excretion = filtration**. So, **clearance of inulin = GFR.** (So it's a glomerular filtration rate marker).
  - ✓ Principle used :

Amount excreted per minute = amount provided for excretion per minute.

***Amount provided for excretion* = GFR * concentration of inulin in plasma or ultrafiltrate**

***Amount excreted* = concentration of inulin in urine * urine output**

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➔ **GFR = concentration of inulin in urine * urine output / concentration of inulin in plasma**

- ✓ **Note** >> the composition of the plasma is the same all over the body so when we take sample for plasma to know the conc. Of (X) in it we take it from any place in the body and not necessarily from the renal artery.
- ✓ **GFR** for inulin is constant because the urine output is (1Ml/min) and as we decrease or increase the inulin conc. in plasma the urine conc. Of inulin will decrease or increase accordingly because what is filtered is going to be excreted. So GFR stays the same.

Clearance of inulin means volume of plasma that provides inulin for excretion in the urine /minute and because inulin excretion comes for the filtration only so clearance of inulin = **GFR**

Clearance of inulin >> GFR
Clearance of PAH >> RPF

- ✓ But inulin is an exogenous substance so it is only used for research purposes and not as a clinical test. In clinical tests we use creatinine.

- **Creatinine**:

✓ 1. freely filtered
2. Not reabsorbed
3. Slightly secreted (10% secretion):
So we expect it to **overestimate** the GFR (because this 10% secretion will increase the amount of createnine in the urine that's supposed to be from filtration ONLY. So it'll appear like filtration has increased 10%).
However, **GFR** won't be overestimated
HOW??!!
This's because of the way we measure the concentration of creatinine in the plasma , we measure TOTAL creatinine which's divided into 90% free &10% bound to albumin and this bounded 10% CAN'T BE filtered .we don't care about it but it's measured same as the 10% secretion . This extra 10% creatinine in the plasma will cancel the extra 10% creatinine in urine.

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- **Creatinine clearance = (Urine conc. / Plasma conc.)*urine output**

Renal diseases don't follow all or none principle just like all other diseases. they have degrees & stages (4 stages):

Reduction in GFR that doesn't go below 50% is called: **decreased renal preserve.**

20%-49%: renal insufficiency

5%-19%: renal failure

<5%: end stage renal failure.

Please refer to the slides 7aseithom mofedeen .

"قد رسمناك على الدُّفلى ، وقامات السنابل

غابة للأعين السود ، وحقلا من جدائل

وأقمنا لك في بال المواويل.. منازل

فاكتبي أسماءنا في دفتر الحب: نشامى

يعشقون الورد لكن.. يعشقون الأرض أكثر"

و ما توفيقي الا بالله ..

راية عبدالحميد المجالي

Ta7eiie la #Medteam :')

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