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Urine formation

Remember : what is GFR?, starling force , normal value of GFR

Factor affecting GFR (glomerular filtration rate)

1- Glomerular capillary pressure :

Note: the glomerulus is supplied with blood via Afferent arteriole , and then the blood is transferred via Efferent arteriole .

Afferent arteriole → glomerular capillary → efferent arteriole

a) Renal blood flow (GFR) :

↑RBF → ↑GBR → ↑glomerular capillary pressure → ↑ GFR

b) Diameter of efferent arteriole :

To rise the glomerular capillary pressure the Afferent arteriole is dilated (vasodilatation)

↑ diameter (dilatation) → ↑GBR → ↑glomerular capillary pressure → ↑GFR

c) Diameter of Efferent arteriole :

To raise the glomerular capillary pressure the Efferent arteriole is constricted (vasoconstriction)

↓ diameter (constriction) → ↑ GBR → ↑ glomlular capillary pressure → ↑ GFR

d) Sympathetic stimulation :

The nervous system part that activates fight or fright response
→ your GFR constant sympathetic when you are mild and moderate which means → no vaso constriction
→in severe stress ex: a shock resulting from extreme loss of blood , the sympatatic nervous system leads to vasoconstriction of Afferent arteriole casing GFR to be dropped down .
Constriction of afferent arteriole → ↓ GFR → ↓ glomerular capillary pressure → ↓ GFR

GFR and RBF must be nearly constant to maintain Homeostasis which means :- effective filtration , reabsorption and secretion
So how can we preserve a constant blood supply for the kidney , even the main arterial blood pressure is affected ? by autoregulation

Note :- kidney has a constant blood supply as long as the blood pressure range is between (80-180), if it gets higher the glumeruli's function will be affected and RBCs and proteins will be present in the filtrate and we're gonna have something called (glomerular injury)

• Tubuloglomerular feedback mechanism :

When the renal blood flow is low →↓GFR
So , the kidney starts to reabsorb Na , Cl (in the ascending limb of loop of Henle)to raise blood volume , when the filtrate reaches distal convoluted tubule , Macula densa cell (which have osmoreceptor to sense Na , Cl concentration in filtrate) will indicate the loss of Na , cl ions which have been reabsorbed . this leads to :- stimulating Juxta glomerular cells to secret the renin which ends with the formation of angiotensin (II) causing vasoconstriction of Efferent arterioles → ↑ GFR

Myogenic mechanism:-

Note:- all blood vessels wall are consisted from 3 layers :

1- Intima (internal layer)
2- Media
3- Adventitia (external layer)

**What differentiates arteries from arterioles is that , arterioles have smooth muscle fibers in their wall allowing it to contract → to prevent the blood supply constant

** These smooth muscle have stretch activated receptors

Receptors function to prevent stretch , dilation of arterioles walls by making reflex contraction

→if the blood supply is high → the Afferent arteriole will be stretched → smooth muscle contraction of Afferent arteriole → stopping (inhabiting) the high blood pressure to reach the delicate glomerular capillary casing injuries

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How is urine formed ?

The filtrate is the fluid that is being filtrated along the tubules until it reachs the collecting duct , it called urine

Tubular reabsorption :

Tubular reabsorption is occurred for solutes (Na^+ , K^+ , Cl^- , $HCO3^-$)

**$HCO3^-$: bicarbonate

Reabsorption can occur by two route :

1- Trans cellular route :

Lumen of the tubule → apical membrane → inside the cell → basolateral border

2- Para cellular route (a type of cell junction)

** both end in interstitial fluid

Each solute has a specific reabsorption mechanism

*Renal handling of sodium ions :-

Na is the only solute that can be reabsorbed at all tubule segments ‹ except thin loop of Henle› and when Na+ ions enter the cell , many other substances enter with as pairs like (glucose , amino acids , H+ , K+ , cl-…)

1- Proximal convoluted tubule ‹length: 15 mm› (Reabsorption of Na+ steps) :-

a) First half (7 mm)

Apical border of the cell → Na+ is diffused down <u>electrical</u> gradient

↓

The Na^+-k^+ pump on the basolateral border of the cell cases a net negative charge on the apical border of (-1) , by pumping 3 Na+ ions outside and 2 K+ ions inside

This negative charge attacks Na ions toward (diffusion of Na+)

Basolateral border of the cell → Na+ is transported actively by Na+-k+ pump (primary active transport)

*beside sodium , other substance : glucose , amino acid are transported by co-transport (symport)

**Notice :- that secondary active transport occurs for glucose and amino acids or hydrogen, while Na+ is transported via Na-K pumps via primary active transport

In ACIDOSIS :- (excess hydrogen ions)

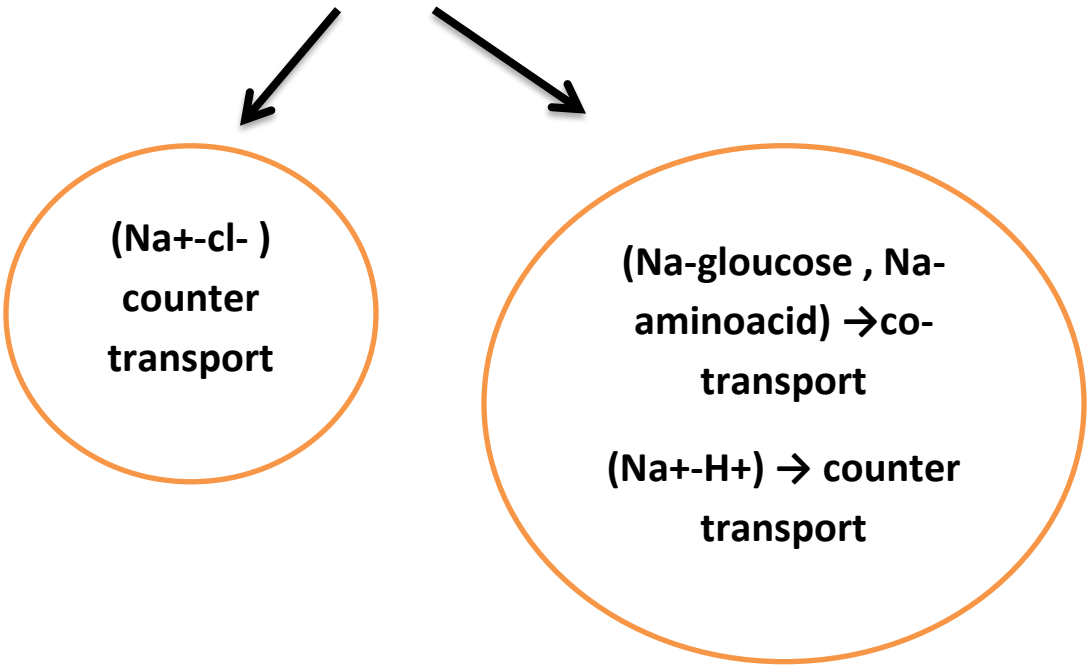
to get rid of these hydrogen ions → Na+-H+ counter transport is activated and H+ ions are released with urine .

In ALKALOSIS:- (exess HCO3- or H+ deficiency)

we need to preserve H+ ions , and HCO3- is released with urine

** Na+-H+ counter transport is not activated

- **Middle and late half**
- Na+ and cl- are reabsorbed via co-transport
  → at this point , all previously absorbed substances (glucose , amino acid ….) are totally transferred to the blood
  Summary :- the filtrate is transferred → glomerular capillary → bowman's capsule →
  Proximal convoluted tubule → loop of Henle



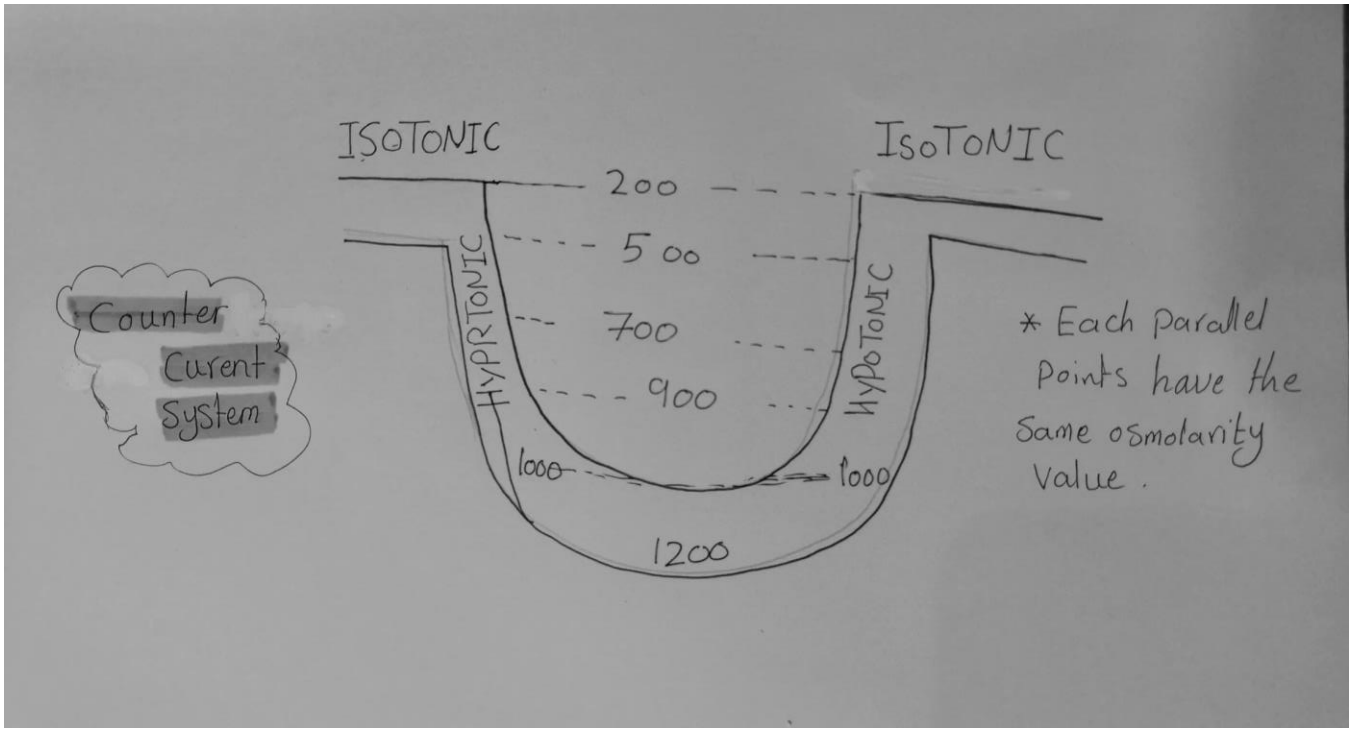
2- Loop of Henle :

Remember that we are transfer solutes which are osmotically active , attraction water toward and causing osmolarity changes in each segment
→ until we reach the late part of the proximal tubule , we are absorbing water as much as we absorb solute so the fluid is (ISOTONIC)

Descending limb of loop of Helen → filtrate passes rapidly , no solute reabsorption , But this segment is freely permeable to water , so large amount of water is reabsorbed . Solutes in the filtrate became concentrated so the fluid is HYPETONIC

Ascending limb of loop of Henle →

- thin segment → sodium reabsorption following chloride (counter transport)
- thick segment → Na+-K+-2Cl- pump (special active pump acting as a result of solutes reabsorbing , the concentration of solutes (ions) starts to go down gradually causing the fluid to become HYPOTONIC
- in addition to reabsorption of Mg , Ca … → this segment is less permeable to water reabsorption



3- Distal Convoluted Tubule :-

a) **Early distal tubule** → as the ascending limb of Henle :-

- Has Na+-k+-2cl- pump
- Ca+2 reabsorption

Medication related to renal handling to Na+ reabsorption :-

- Loop diuretics Furosemide (Lasix)
  Furosemide inhibits Na+-k+-2cl- pump in loop of Henle making it non functioning → no reabsorption of Na , K , Cl which will attract water toward the lumen → water and ions will be released with urine
  ** patient taking this medication , should have supplement of Na+-K+-cl- to restore the loss of these ions .

- Carbonic anhydrase inhibitor :-
  inhibit carbonic anhydrate enzyme which is responsible for catalyzing this reaction :-

$$CO_2 + H_20 \rightleftharpoons H_2CO_3 \rightleftharpoons H^+ + HCO_3^-$$

In proximal convoluted tubule , as a result of carbonic anhydrase inhibitors , the reaction will stop on forming H+ , HCO3- Prevention CO2 to be bound to H2O to form H2CO3 again which are osmotically active molecules , attracting water and acting as diuretics

نسأل الله لنا و لكم التوفيق

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لا تنسونا من صالح دعائكم

#لجنة التبيض