Handling of certain important solutes by the renal tubules:

Sodium handling (Na):

●Sodium is filtered in large amounts through the glomeruli, **but 96% of filtered sodium is reabsorbed** as follows:

1)proximal convoluted tubules: (Obligatory)

65-67% of filtered sodium (67% of the 96%) is reabsorbed by the proximal convoluted tubules by a **primary active process (sodium potassium pump)**

2)Loop of Henle: (Obligatory)

25% of filtered sodium is reabsorbed through the ascending limb of loop of Henle

3) distal tubules and collecting ducts: (facultative)

variable amounts (1-6% (of 96%)) of filtered sodium is reabsorbed through the distal and collecting ducts **according to our body needs,** it occurs under the control of **aldosterone hormone**

دلوقتي اللي بيحصل ان 90-92% من ال 96% دول بيحصلو اجباري مش بمزاجي ولا اقدر اتحكم فيهم لكن اخر حبه في ال 96% دول اللي هم من 1-6% في الميه دول اختياري دول الهرمون اللي يقدر يتحكم في ويزودهم او يقللهم، يعني لو مثلا انا ضغطي عالي والملوحه عاليه في الدم بتاعي ساعتها ممكن نخليها 1% بس، طب لو انا ضغطي واطي ومحتاجه ملوحه علشان ارفع ضغط الدم؟ يبقى ساعتها هنخليها توصل ل 6% وهكذا (اي حاجة في جسمنا hormonalتبقى variable)

Q) What is the significance of the 96% reabsorption of Na?

Because salts **control the blood volume** (by applying osmotic pressure which pulls water to the vessels) **and so it controls the blood pressure**, so, if there's no reabsorption (the sodium and salts are lost in urine), the blood volume and pressure will fall and **lead to shock**

الاملاح بتزود حجم الدم وبالتالي بتزبط ضغط الدم فا لو خسرناها في ال urineوما حصلش reabsorption ساعتها ضغط الدم هيوقع جامد و ممكن يعمل shock

Q)How does reabsorption take place? الدكتور شرحها بس مش في الكتاب فا اقروها احطياتي

دلوقتي ال Na كانت جوه ال tubule يعني جوه انبوبه ، الخلايا اللي هتعدي من خلالها ليها ناحيتين، ناحيه بتواجه الانبوبه من جوه فا بنسميها **lumenal border** وناحية بتواجه ال blood اللي بره فا بنسميها **basolateral border** ، ال basolateral دا فيه Na-K-pump، فا لما ال Na يخرج برة الخلايا actively بالpump دي ،هايقل عدده جوة الخلايا، فا كده كميه الصوديوم جوه الlumen اكثر من اللي جوه الخلايا نفسها، فا كده الصوديم هيدخل الخلايا من الlumenal border من غير pump معتمد على الconcentratiom gradient (يعني passively) و يرجع يزيد جوة الخلايا تاني و تشتغل ال pump تاني و هكذا

Note:

90% of the kidneys energy are used in **Na-K pump**, as it is the most important process ,because as Na transports by primary active transport, it pulls most of the other important ions with, it **either electrically** (as Cl or HCO3)**, or by secondary active transport** as glucose

الصوديوم لما بيتنقل بيسحب معه معظم الايونات، يا اما علشان الشحنه يا اما ان الحاجه الثانيه دي تستغل الطاقه اللي الNa اتنقل بيها فا تتنقل هي بعده علطول باستخدام الطاقة دى، و دي اسمها secondary active transport، يعني من الاخر لو ال pump دي وقفت او باظت، معظم الايونات هتفضل مكانها مش هتتحرك

Glucose reabsorption:

●Glucose is freely filtered through the glomerular membrane so:

- it's concentration in the filtrate = it's concentration in plasma = nearly 100 mg/dl

●Normally all of the filtered glucose is reabsorbed in the proximal convoluted tubules **(100% reabsorption)**

يعني كميه ال glucoseاللي اترشحت من الدم هي نفسها الكميه اللي هترجع للدم يعني ما فيش اي حاجه هتنزل في ال urine، وبكده كميه الجلوكوز في الدم اللي كانت داخله الكليه هي نفسها الكميه اللي هتخرج في الدم اللي خارج من الكلية

●But when the level of glucose increases above a certain value it will not be completely absorbed and **will appear in urine (glucosuria)**

●Glucose and sodium are cotransported from the tubular lumen to the cells **(through lumenal border)** by the same carrier **by secondary active transport that needs energy** (as explained above), and then it will leave the tubular cells **through**

the basolateral border by facilitated diffusion (passive not active, so no energy needed, but it also needs a carrier as in secondary transport)

ال Na يسبأ والجلوكوز يحصله ، اه مختلف عنه شوية بس من غيره مايحصلوش reabsorption

Renal threshold of glucose:

It is the Plasma level of glucose at which glucose starts to appear in urine, it's about 180 mg/dL in venous blood

هي النقطه اللي عندها هيبدا الجلوكوز يظهر في الurine ، يعني لسه ما ظهرش بس اول ما هنعديها هيظهر

Tubular maximum for glucose (TM):

It is the **maximum amount** of glucose that can be reabsorbed by the tubules per minute, it's about **300 mg/min in females** and **375 in males** ,depending on the amount of carrier present in the tubules (females have less number)

Glucosuria:

It's the appearance of glucose in urine due to **incomplete reabsorption,** due to:

1)diabetes mellitus: where **plasma glucose levels increase above renal threshold** (above 180 mg/dl) and so all carriers become busy with glucose **(completely saturated)** and so, the excess glucose have **no carriers to undergo reabsorption**, so it appears in urine

2) renal glucosuria: a congenital disease causing a **defect in the glucose transport mechanism in the tubules,** (a deffect in the carriers for example) leading to the appearance of glucose in urine although **plasma glucose level is normal** (below 180 mg/dl)

Water reabsorption:

●**Water reabsorption is directly related to Urine concentration**

يعني كل ما الreabsorption بتاع الميه يزيد، كل ما تركيز الurine يزيد

●Normally 180 Liters of fluid is filtered through the glomeruli each day, while the average daily urine volume is about 1 L (احنا بنعمل في اليوم ليتر واحد بس يعني من ال180) ,this means that about 99% of the filtered water is reabsorbed (about 179 L/day), we can also tell that according to GFR, 124 ml/min are reabsorbed from the filtrate which is 125 ml/min

Types of H20 reabsorption:

1-obligatory water reabsorption:

●It is the amount of water that will be reabsorbed from the glomerular filtrate Independent of any hormonal effect

●It's about **87%** of filtered water:

- 65% in PCT
- 15% in loop of Henle
- 7% in distal tubules and collecting ducts **(But mostly distal only)**

2-Facultative water reabsorption (concentrating ability of the kidney):

●It is the method responsible for urine concentration

●It depends on the **creation of a high osmotic gradient** (pressure) in the kidney interstitium

لما الملوحة تزيد في الكلية بره الtubules، الملوحة العالية دي هاتفضل تسحب مياه ناحيتها بالosmosis، فا بكدة المياه تخرج بره الtubules

●And this osmotic gradient is **due to the presence of a high content of Na and urea** (salts)

●And their high concentration is **created by the countercurrent system** of the loop of Henle, where Na and urea are only allowed to pass **out of the tubular fluid into the deep kidney interstitium**, and so increase its osmotic pressure

◇The ascending and descending limbs of Henle are responsible for the countercurrent system◇

●This system allows the kidney to concentrate urine i.e **excrete urine with osmolarity higher than plasma**, (osmolarity in plasma is 300 mosmol/L while osmolarity in urine which is done by this system can reach 1400 mosmol/L)

يعني الfacultative هو اللي مسؤول عن تركيز الurine اما الobligatory عن ال water reabsorption

●This type is responsible for the **remaining 13%**, variable amount of this water is reabsorbed depending on the presence of **antidiuretic hormone (ADH)**

احنا قولنا اي حاجة variable تبقي بهورمونات، طب و ليه الكمية ممكن تتغير؟ اصل لو مثلا انا عندي جفاف والتركيز عالي في دمي، هحتاج ان الهرمون ده يعمللي reabsorption ل ال 13% الباقيين كلهم، طب لو انا شاربه ميه كثير وكده كده في ميه كتير في جسمي وفي دمي ؟ ساعتها هاحتاج اني اقلل ال 13% دول و اخليهم اثنين او ثلاثه بس

●This hormone **opens water channels** in the distal and collecting tubules **(but mostly in the collecting tubules)** which increases water permeability **allowing water reabsorption to the Blood by osmosis, and decreasing its excretion in urine**

●This hormone is **synthesized by hypothalamus and secreted from the posterior pituitary gland,** and this secretion increases whenever the body needs for water increases

It's detected by:

1)**Osmoreceptors** in the **hypothalamus** which are stimulated by an increase in the osmotic pressure of the extracellular fluid

يعني دلوقتي لو ال blood volume قل و خسرنا مياه، زي في حالات النزيف مثلا، كدة تركيزه هايزيد، او لو الملوحة زادت في دمه ، فا كدة المستقبلات دي تبعت لي الhypothalamus تقول له صنع بسرعه ADH عشان عايزين نزود الدم بمياه

2)**volume receptors** in the **atria** which detect changes in blood volume, ADH increase when blood volume decreases

دي مستقبلات في ال atria بتشتغل طول ما حجم الدم مظبوط او عالي لكن كل ما حجم الدم يقل زي في النزيف مثلا، او ال venous return يقل زي لو الضغط واطي، شغلها بيقل ويبدا يحصلها inhibition، و ال inhibitionبتاعها بيstimulate ال ADH secretion

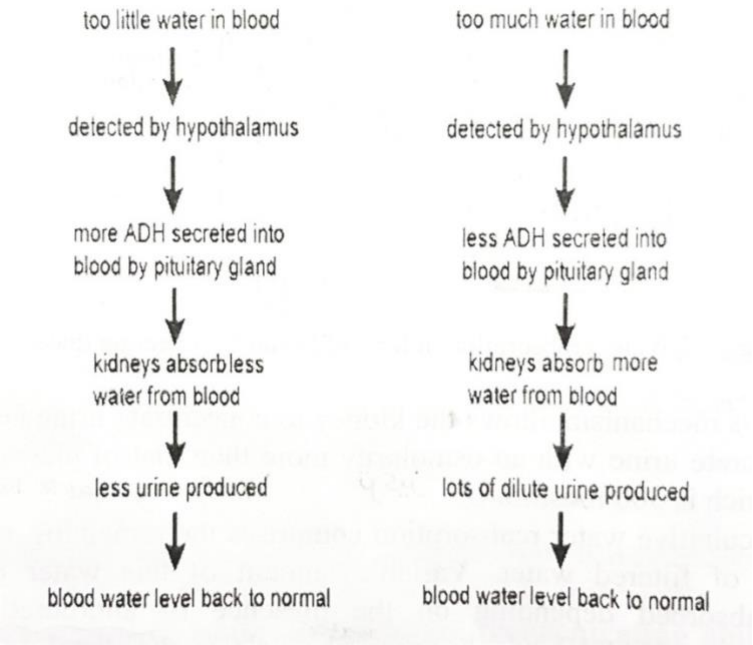
Notes:

●ADH concentrates urine and dilutes blood, while aldosterone increase osmolarity (ملوحة)of blood and excrete in urine K and H instead of the reabsorbed Na

●The countercurrent system is important, to complete the water reabsorbrion in case of ADH difficiency

Q)ADH functions in the kidney only (F)

Because it also helps in regulation of blood volume (circulation)



Plasma clearance: (an important function of the kidney)

●**It is the amount of plasma cleared** from a particular substance which is excreted in urine/minute

يعني كمية الplasma اللي تم تنضيفها و اللي شيلنا منها الشوائب، مش كمية الشوائب اللي اتشالت، و عشان نقول ان التنظيف حصل لازم الشوائب دي تنزل في الurine

●It denotes renal handling of this substance

بتدل على قدرة الكلية من التحكم و التخلص من المادة دي

●Calculation:

Amount of substance cleared/min =amount of substance excreted in urine/min

◇amount=volume × concentration◇

So: C×P = U×V

- C= the volume of plasma cleared/min (unknown)
- P= the concentration of the substance in plasma (known)
- U= the concentration of the substance in urine (known)
- V= the volume of urine/min (known)

So, to calculate the only unknown: C= UxV /P

●If its clearance is **zero**, then this substance is **completely reabsorbed** ex:glucose

لان كميه الجلوكوز في البلازما اللي كانت داخله الكلية هي نفسها الكميه اللي هتخرج في البلازما برة الكلية، فا محصلش تنظيف لأن مافيش حاجة نزلت الurine

●if its clearance is **equal to the glomerular filtration rate** (125 ml/min), then this substance **is neither reabsorbed nor secreted** ex: inulin

يعني لو الكميه اللي تم تنظيفها هي نفسها الكميه اللي تم ترشيحها يبقى ده معناه ان الماده دي لا امتصت ثاني في الدم ولا زاد عليها

●if its clearance is **less than 125 ml/min,** then this substance is **partially reabsorbed** ex: urea, K,Na,water,....

حصل شويه reabsorption فا الكميه اللي نزلت في ال urine بقت اقل من كميه الترشيح، سواء الreabsorption دا 2% او 96% المهم انه اللي جرج في ال urine اقل من الfiltrate

●If its clearance is **more than 125 ml/min** (from 125 and just before 650), then this substance is **partially secreted by renal tubules** ex: creatinine ,or **completely secreted** ex:PAHA

◇PAHA's clearance **is 650 ml/min** because it's completely secreted◇

دايما الكلية بيجلها 650 ml/min و بترشح منهم 125ml/min زي ما قلنا قبل كدة يعني يتبقي 525 في الperitubular capliiaries فا يا اما يحصل لحبة منهم secretion فا الclearance يبقا اكتر من 125 يا اما كلهم يحصلهم secretion فا الclearance يبقي 650ml/min

◇**PAHA** (para aminohippuric acid) is used in **measuring the renal plasma flow** because the **normal renal plasma flow is 650 ml/min**◇

Dr.Mina's summary for the plasma clearance:

Clearance	Behavior of the substance	Example
125 ml/min	Neither reabsorbed nor secreted	Inulin
< 125 ml/min	Partially reabsorbed	Urea, K^+
Zero	Completely reabsorbed	Glucose
125-650	Partially secreted	Creatinine
650 ml/min	Completely secreted	PAHA
> 650 ml/min	Completely secreted + synthesized by kidney	Ammonia