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RENAL PHYSIOLOGY ASSIGNMENT

Explain Urine formation and concentration

Urine is one of the body's waste products. It is primarily composed of water and urea. Urea is a special nitrogenous waste compound that the body must routinely remove. By filtering the blood the nephrons perform the following functions:

(1) regulate concentration of solutes in blood plasma; this also regulates pH

(2) regulate water concentrations; this helps regulate blood pressure

(3) removes metabolic wastes and excess substances

Urine formation occurs in the kidney in three stages: filtration, reabsorption, and secretion.

Filtration

Stage 1: filtration. The kidney is the body's blood filtering system. Blood vessels visit the kidney and enter a special ball of capillaries called the glomerulus. The glomerulus is nestled within a region of the kidney called the Bowman's Capsule. This is where filtration occurs. As blood is pushed through the tiny capillaries, the high-pressure forces some things to pass through the capillary walls. The walls act as a sieve or a filter. Hence, it is called filtration.

Water, sugar, salts, amino acids, nitrogenous wastes, and other tiny things enter the kidney as a substance called the filtrate. Cells and large blood

proteins that cannot fit through remain in the blood vessels. The filtrate entering the kidney is like pre-pre-urine.

Glomerular filtration occurs across the three layers- epithelium of Bowman's capsule, endothelium of glomerular blood vessels, and a membrane between these two layers.

Blood is filtered in such a way that all the constituents of the plasma reach the Bowman's capsule, except proteins. Therefore, this process is known as ultrafiltration.

Reabsorption

Stage 2: reabsorption. The filtrate enters the kidney in the proximal tubule. This region of the kidney is special because many things can be removed from the filtrate. These valuable things are recollected, or reabsorbed, by the body. This is achieved by active and passive transport.

Glucose, certain salts, vitamins, hormones, and amino acids are restored to the body and will not be included in urine. Sometimes, if the body has too much of something then the extra sugar or salt will stay in the filtrate. For example, diabetics with high levels of blood glucose may have glucose in their urine since it cannot all be reabsorbed. The filtrate after reabsorption is like pre-urine.

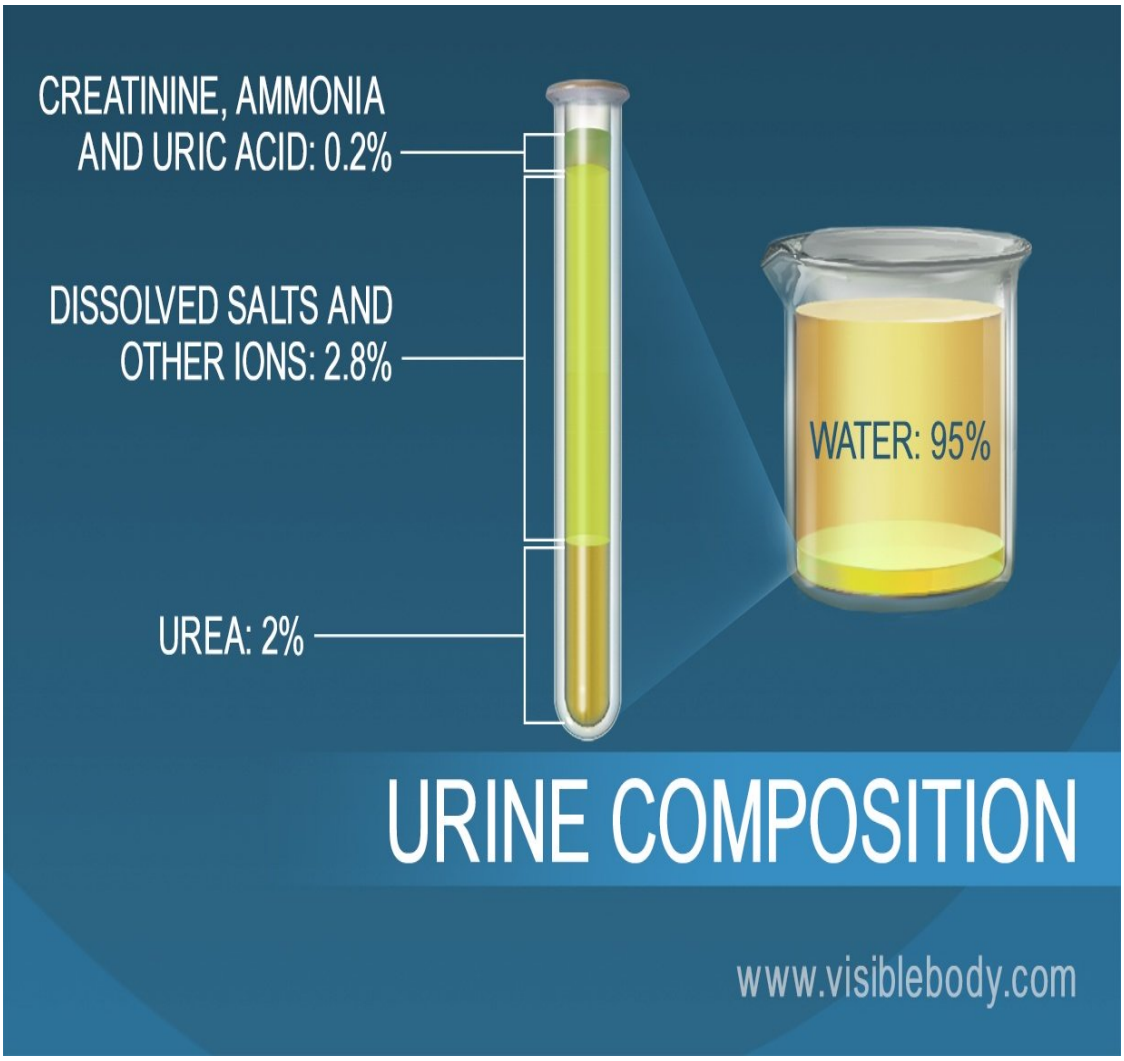
Secretion

Stage 3: secretion. The filtrate then passes through a really neat structure called the Loop of Henle where it gains and loses water and salt. As it leaves the Loop of Henle, it enters the distal tubule, where secretion occurs.

The body sometimes needs to send things on the express route to excretion. For example, toxins are always sent on the fast track out of the body. They do not go through filtration and reabsorption. Instead, they are added, or secreted, directly from the blood vessel into the almost fully formed urine in the distal tubule.

Urine

The urine produced is 95% water and 5% nitrogenous wastes. Wastes such as urea, ammonia, creatinine are excreted in urine. Apart from these, the potassium, sodium and calcium ions are also excreted.



Glomerular Filtration Rate (GFR)

The volume of filtrate formed by both kidneys per minute is termed the glomerular filtration rate (GFR). The heart pumps about 5 L blood per min

under resting conditions. Approximately 20 percent or one liter enters the kidneys to be filtered. On average, this liter results in the production of about 125 mL/min filtrate produced in men (range of 90 to 140 mL/min) and 105 mL/min filtrate produced in women (range of 80 to 125 mL/min). This amount equates to a volume of about 180 L/day in men and 150 L/day in women. Ninety-nine percent of this filtrate is returned to the circulation by reabsorption so that only about 1–2 liters of urine are produced per day.

URINE CONCENTRATION

The final concentration of the urine is very dependent on the amount of liquid ingested, the losses through respiration, faeces and skin, including sweating. When the intake far exceeds the losses, then, in order to maintain homeostasis the rest of the liquid is eliminated through urine. If the fluid intake is low and the losses are high, then the kidney has to concentrate as much as possible the urine in order to maintain homeostasis. As a result the concentration can range from as diluted as 65 to as concentrated as 1200 mOsm/kg. Producing diluted urine is not as problematic as to concentrating it. To achieve the higher concentrations the kidney depends on the juxtaglomerular nephrons that reach deep into the medulla and in the architectural relationship with the vasa recta. As mentioned before the concentration of the interstitial fluid increases in the medulla towards the tip of the renal pyramid. The higher concentrations of the interstitial fluid in the tip of the renal pyramid are achieved because the nephron has the capability of recirculate urea. Urea in the filtrate is not completely reabsorbed and most of it goes into urine. A percentage of the urea in the filtrate diffuses out of the collecting duct into the interstitial fluid. Once in the interstitial fluid urea provides the increase in osmalality that makes the tip of the renal pyramid so concentrated.

The urea circulates between the collecting duct where it diffuses into the interstitial fluid and the thin descending segment of the loop of Henle which is also permeable to urea. At this point it diffuses into the tubule to

reach again the collecting duct.

All the concentration capacity of the nephron can be attributed to the fact that the loop of Henle is in close association or apposition with the extension of the peritubular capillaries which deep in the medulla are called the vasa recta.

The association between these two structures is one that creates a counter current mechanism which permit the removal of all reabsorbed solutes and the water that follows by osmosis out of the medulla into the venous return of the kidney. Otherwise the interstitial fluid would be rapidly diluted or engorged with water and solutes.