Name: Adaja Bilqees Abiola

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URINE FORMATION AND CONCENTRATION

The kidney filter unwanted substances from the blood and produce urine to excrete them.There are three main steps of urine formation;

- Glomerular filtration
- Reabsorption
- Secretion

These processes ensure that only waste and excess water and removed from the body.

GLOMERULAR FILTRATION

During filtration, blood enters the afferent arteriole and flows into the glomerulus where filterable blood components, such as water and nitrogenous waste, will move towards the inside of the glomerulus, and non-filterable components, such as cells and serum albumins, will exit via the efferent arteriole. These filterable components accumulate in the glomerulus to form the glomerular filtrate.

Normally, about 20% of the total blood pumped by the heart each minute will enter the kidneys to undergo filtration; this is called the filtration fraction. The remaining 80% of the blood flows through the rest of the body to facilitate tissue perfusion and gas exchange.

REABSORPTION

The next step is reabsorption, during which molecules and ions will be reabsorbed into the circulatory system. The fluid passes through the components of the nephron (the proximal/distal convoluted tubules, loop of Henle, the collecting duct) as water and ions are removed as the fluid osssmolarity (ion concentration) changes. In the collecting duct, secretion will occur before the fluid leaves the ureter in the form of urine.

SECRETION

During secretion some substances ±such as hydrogen ions, creatinine, and drugs—will be removed from the blood through the peritubular capillary network into the collecting duct. The end product of all these processes is urine, which is essentially a collection of substances that has not been reabsorbed during glomerular filtration or tubular reabsorption.

URINE CONCENTRATION

Urine is mainly composed of water that has not been reabsorbed, which is the way in which the body lowers blood volume, by increasing the amount of water that becomes urine instead of becoming reabsorbed. The other main component of urine is urea, a highly soluble molecule

composed of ammonia and carbon dioxide, and provides a way for nitrogen (found in ammonia) to be removed from the body. Urine also contains many salts and other waste components. Red blood cells and sugar are not normally found in urine but may indicate glomerulus injury and diabetes mellitus respectively.

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.