Aibe sarah nimo

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URINE FORMATION AND CONCENTRATION

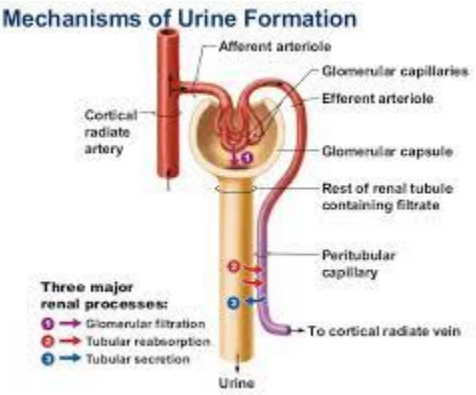
Urine formation is a blood-cleansing function. Normally about 1,300 mL of blood (26% of cardiac output) enters the kidneys and unwanted substances along with water from blood are excreted as urine. The three processes involved in the formation of urine :

- Glomerular filtration
- Tubular reabsorbtion/ selective reabsorbtion
- Tubular secretion

Glomerular filtration : when blood passes through glomerular capillaries the plasma filtered into the bowman's capsule through the filtration membrane (glomerular capillary membrane + basement membrane + visceral layer of bowman's capsule) . all except the plasma proteins , blood cells and other molecules due to their large sizes are not filtered. The filtered fluid is called glomerular filtrate. Filtration takes place because there is a difference between the blood pressure in the glomerulus and the pressure of the filtrate In the glomerular capsule .

Tubular reabsorbtion: when the glomerular filtrate flows through the tubular portion of nephron, both quantitative and qualitative changes occurs. Large quantity of water (more than 99%), electrolytes and other substances are reabsorbed by the tubular epithelial cells. The reabsorbed substances move into the interstitial fluid of renal medulla and then into the blood in the peritubular capillaries. It is also known as selective reabsorbtion because the tubular cells reabsorb only substances necessary for the body. About 7/8 of the filtrate (about 88%) is reabsorbed in proximal convoluted tubule . the brush border of epithelial cells in proximal convoluted tubule increases the surface area and facilitates the reabsorbtion. Tubular reabsorbtion can be regulated by glomerulotubular balance, hormonal factors and nervous factors.

Tubular secretion: tubular secretion is process by which the substances are transported from blood into the renal tubules. It ia when substances not required and foreign materials eg drugs like penicillin and aspirin which are cannot be filtered through the filtration pores because of the short time they remain in the glomerulus or because the molecules are too large therefore they are cleared by secretion from the peritubular capillaries into the filtrate within the convoluted tubule. Tubular secretion of hydrogen ions (H+) is important in maintaining normal blood pH . other substances secreted are potassium, ammonia, urea.



URINE CONCENTRATION

The ability of the kidney to form urine more concentrated than plasma is essential for survival of mammals that live on land, including humans. Water is continuously lost from the body through various routes, including the lungs by evaporation into the expired air, the gastrointestinal tract by way of the feces, the skin through evaporation and perspiration, and the kidneys through excretion of urine. Fluid intake is required to match this loss, but the ability of the kidneys to form a small volume of concentrated urine minimizes the intake of fluid required to maintain homeostasis, a function that is especially important when water is in short supply. When there is a water deficit in the body, the kidneys form concentrated urine by continuing to excrete solutes while increasing water reabsorption and decreasing the volume of urine formed. The human kidney can produce a maximal urine concentration of 1200 to 1400 mOsm/L, four to five times the osmolarity of plasma. The basic requirements for forming a concentrated urine are (1) a high level of ADH, which increases the permeability of the distal tubules and collecting ducts to water, thereby allowing these tubular segments to avidly reabsorb water, and (2) a high osmolarity of the renal medullary interstitial fluid, which provides the osmotic gradient necessary for water reabsorption to occur in the presence of high levels of ADH. The renal medullary interstitium surrounding the collecting ducts is normally hyperosmotic, so when ADH levels are high, water moves through the tubular membrane by osmosis into the renal interstitium; from there it is carried away by the vasa recta back into the blood. Thus, the urine-concentrating ability is limited by the level of ADH and by the degree of hyperosmolarity of the renal medulla. Normally the distal convoluted tubule and collecting ducts are impermeable to water but the presence of antidiuretic hormone makes them permeable resulting In water reabsorption. A large amount of water is removed from the fluid while passing through the distal convoluted tubule and the collecting duct. So, the urine becomes hypertonic with an osmolarity of 1,200 mOsm/L

In addition , the loop of henle function as the countercurrent multiplier which is responsible for development of hyperosmolarity of medullary interstitial fluid and medullary gradient. Other factors responsible are reabsorbtion of sodium from collecting duct and recirculation of urea. Also, vasa recta

functions as countercurrent exchanger. It is responsible for the maintenance of medullary gradient, which is developed by countercurrent multiplier.