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QUESTION

Explain urine formation and concentration

Urine formation is a blood cleansing function. Normally, about 1,300mLof blood (26% of cardiac output) enters the kidneys. Kidneys excrete the unwanted substances along with water from the blood as urine. Normal urinary output is 1L/day to 1.5L/day.

Processes of Urine Formation

When blood passé through glomerular capillaries, the plasma is filtered into the bowman capsule. This process is called glomerular filtration.

Filtrate from Bowman capsule passes through the tubular portion of the nephron. While passing through the tubule, the filtrate undergoes various changes both in quality and in quantity. Many wanted substances like glucose,amino acids, water and electrolytes are reabsorbed from the tubules. This process is called tubular reabsorption. And, some unwanted substances are secreted into the tubule form peritubular blood vessels. This process is called tubular secretion or excretion. Thus, the urine formation includes three processes:

1. Glomerular filtration
2. Tubular reabsorption
3. Tubular secretion.

Among these three processes filtration is the function of the glomerulus. Reabsorption and secretion are the functions of tubular portion of the nephron.

* GLOMERULAR FILTRATION

Glomerular filtration is the process by which the blood is filtered while passing through the glomerular capillaries by filtration membrane. It is the first process of urine formation. The structure of filtration membrane is well suited for filtration.

Filtration Membrane

Filtration membrane is formed by three layers:

1. Glomerular capillary membrane
2. Basement membrane
3. Visceral layer of Bowman capsule.
4. Glomerular capillary membrane

Glomerular capillary membrane is formed by single layer of endothelial cells, which are attached to the basement membrane. The capillary membrane has many pores called fenestrae or filtration pores with a diameter of 0.1

1. Basement membrane

Basement membrane of glomerular capillaries and the basement membrane of visceral layer of Bowman capsule fuse together. The fused basement membrane separates the endothelium of glomerular capillary and the epithelium

1. Visceral layer of Bowman capsule

This layer is formed by a single layer of flattened epithelial cells resting on a basement membrane. Each cell is connected with the basement membrane by cytoplasmic extensions called pedicles or feet. Epithelial cells with pedicles are called podocytes. Pedices interdigitate leaving small cleft-like spaces in between. The cleft-like space is called slit pore or filtration slit. Filtration takes place through these slit pores.

Concentration of Urine

Everyday 180L of glomerular filtrate is formed with large quantity of water. If this much of water is excreted in urine, body will face serious threats. So, the concentration of urine is very essential. Osmolarity of glomerular filtrate is same as that of plasma and it is 300 mOsm/L. But, normally urine is concentrated and its osmolarity is four times more than that of plasma, i.e. 1,200mOsm/L. Osmolarity of urine depends upon two factors:

1. Water content in the body
2. Antidiuretic hormone (ADH).

Mechanism of urine formation is the same for dilute urine and concentrated urine till the fluid reaches the distal convoluted tubule. However, dilution or concentration of urine depends upon water content of the body.

* Formation of Dilute Urine

When, water content in the body increases, kidney excretes dilute urine. This is achieved by inhibition of ADH secretion from posterior pituitary. So water reabsorption from renal tubules does not take place leading to excretion of large amount of water. This makes the urine dilute.

* Formation of Concentrated Urine

When the water content in body decreases, kidney retains water and excretes concentrated urine. Formation of concentrated urine is not as simple as that of dilute urine. It involves two processes:

1. Development and maintenance of medullary gradient by countercurrent system
2. Secretion of ADH

* MEDULLARY GRADIENT
* Medullary Hyperosmolarity

Cortical interstitial fluid is isotonic to plasma with the osmolarity of 300 mOsm/L. Osmolariy of medullary interstitial fluid near the cortex is also 300mOsm/L. However, while proceeding from outer part towards the inner part of medulla, the osmolarity increases gradually and reaches the maximum at the inner most part of medulla near renal sinus. Here, the interstitial fluid is hypertonic with osmolarity of 1,200mOsm/L.

This type of gradual increase in the osmolarity of the medullary interstitial fluid is called the medullary gradient. It plays an important role in the concentration of urine.