Department of Anesthesia Techniques
Title of the lecture:- Renal Physiology

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General Urinary System Physiology (Control & Clinical)

General Functions of Renal (Urinary) System

- Produce & expel urine

A- Regulate the volume and composition of the extracellular fluid

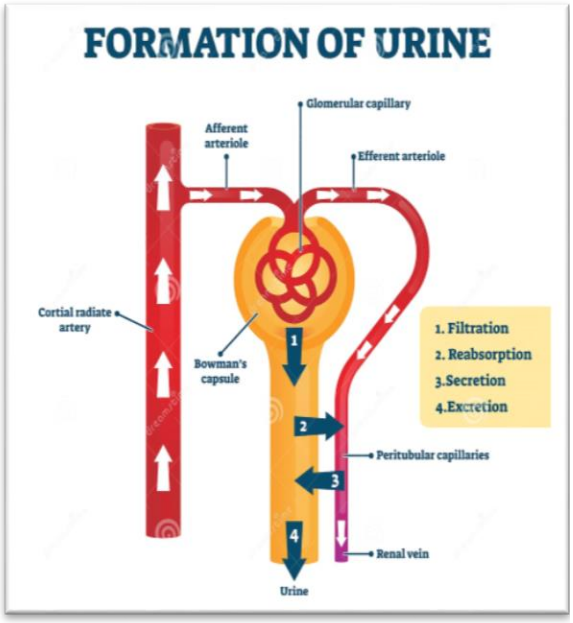
- Control pH
- Control blood volume & blood pressure
- Controls osmolarity –
- Controls ion balance

B- Production of hormones

- Renin

Urine Formation

1. Filtration
2. Reabsorption
3. Secretion
4. Excretion



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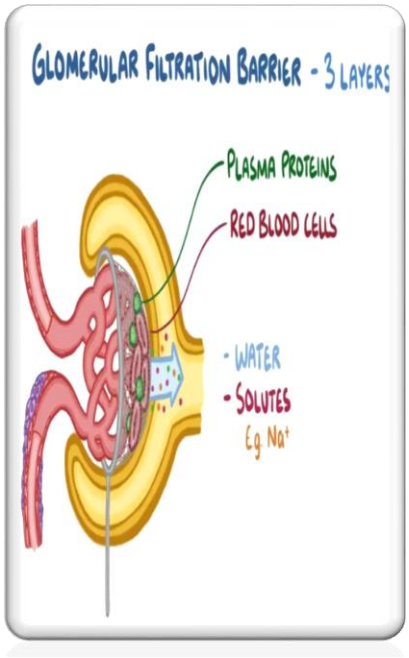
Glomerular Filtration

A filtrate derived from blood plasma in the glomerulus must pass though a basement membrane of the glomerular capillaries and through slits in the processes of the podocytes, the cells that compose the inner layer of the glomerular (Bowman's) capsule.



- The glomerular ultra-filtrate, formed under the force of blood pressure, has a low protein concentration

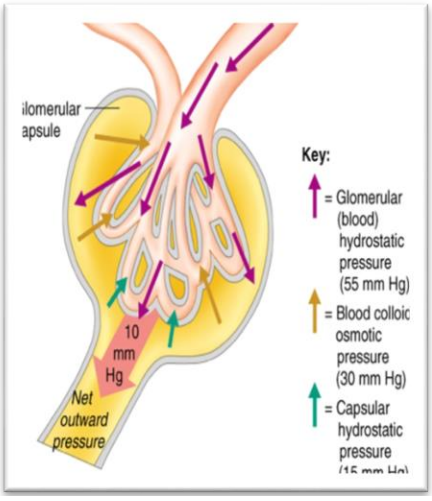
- Filtration Pressure

Hydrostatic and Colloid osmotic pressure inside the glomerular capillaries and bowman's capsule

Regulation of GFR

The glomerular filtration rate (GFR)

Is the volume of filtrate produced by both kidneys each minute. It ranges from 115 to 125 ml/min.



Factors Regulating GFR

1. Constriction or dilation of the afferent arterioles by Sympathetic innervation
2. Auto regulation by Intrinsic mechanisms of renal blood flow

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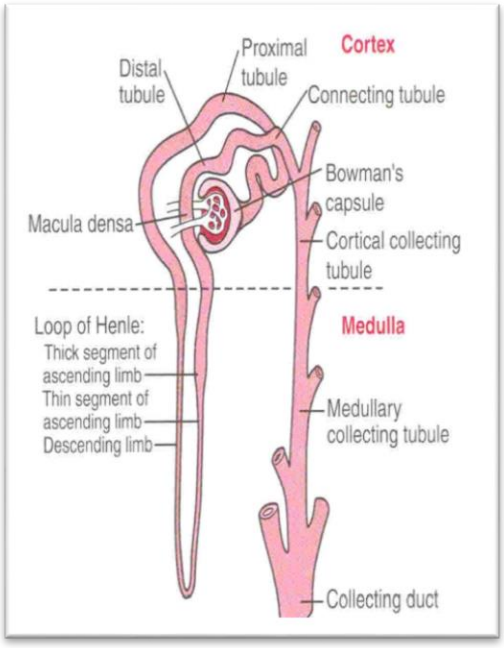
Reabsorption of Salt and Water

I. Approximately 65% of the filtered salt and water is reabsorbed across the proximal convoluted tubules by the following mechanism:

a.Sodium is actively transported, chloride follows passively by electrical attraction, and water follows the salt out of the proximal tubule

b. Salt transport in the proximal tubules is not under hormonal regulation.

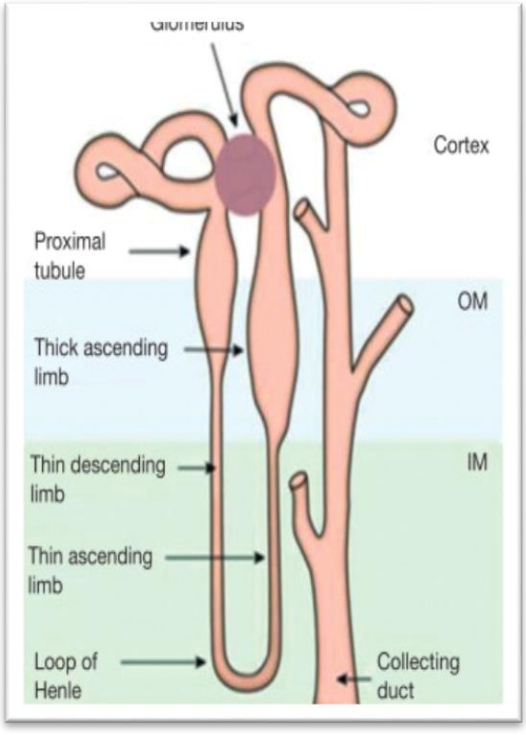


II. The reabsorption of most of the remaining water occurs as a result of the action of the countercurrent multiplier system in the distal tubules by the following mechanism:

a . Sodium is actively extruded from the ascending limb, followed passively by chloride

b . Since the ascending limb is impermeable to water, the remaining filtrate becomes hypotonic.

C . Because of this salt transport and because of countercurrent exchange, the tissue fluid of the medulla becomes hypertonic.



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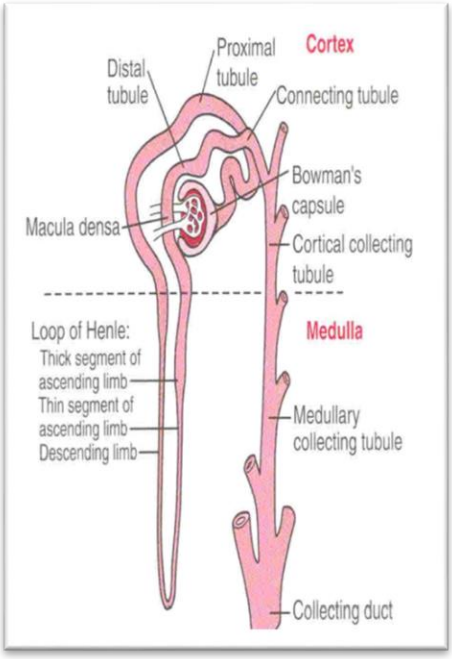
III. The final stage of reabsorption occurred in the collecting duct which is permeable to water but not to salt in the following mechanism:

a. As the collecting ducts pass through the hypertonic renal medulla, water leaves by osmosis and is carried away in surrounding capillaries.

b. The permeability of the collecting ducts to water is stimulated by antidiuretic hormone (ADH).



Excretion & Clearance

The excretion rate of a substance (x) depends on:

– The filtration rate of x

– If x is reabsorbed, secreted or both

Excretion = Filtration – reabsorption + secretion

Clearance Rate

- It is done by testing a known substance that should be filtered, but neither reabsorbed or secreted. 100% of the filtered substance is excreted and by monitoring plasma levels of the substance, a clearance rate can be determined.

1- Inulin (a plant product) is filtered but neither reabsorbed nor secreted. Its clearance is thus equal to the glomerular filtration rate.

2- Some of the filtered urea is reabsorbed. Its clearance is therefore less than the glomerular filtration rate.

3- Normally all of the filtered glucose is reabsorbed.

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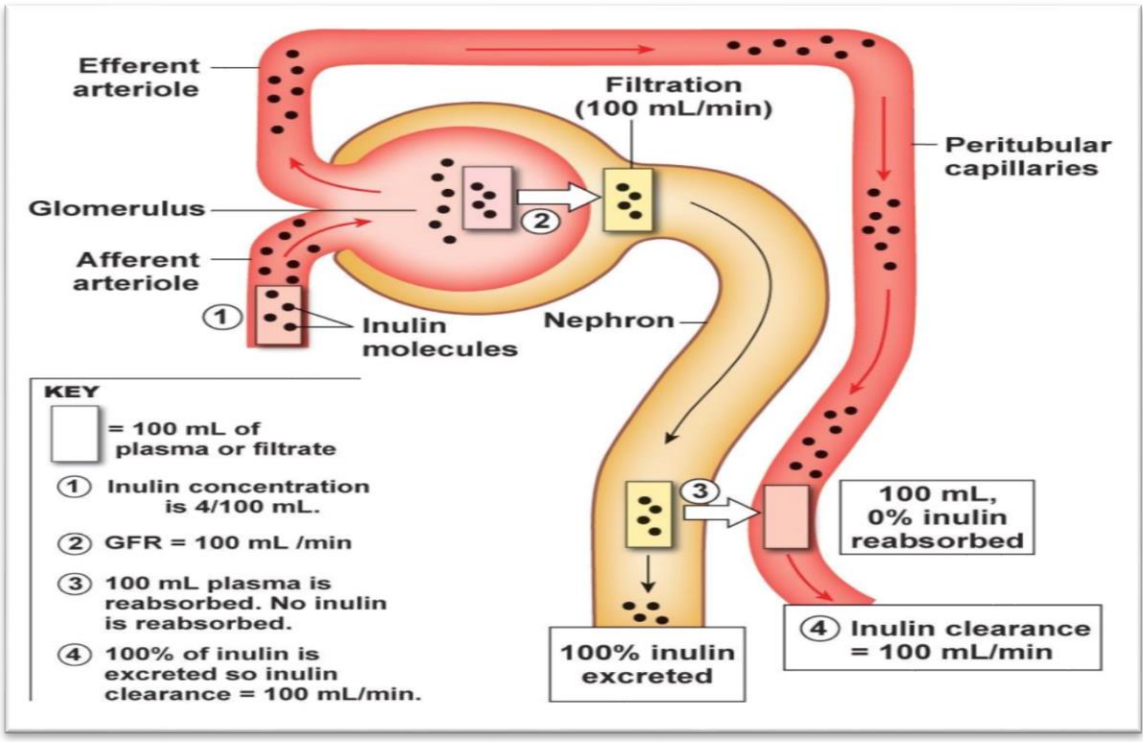
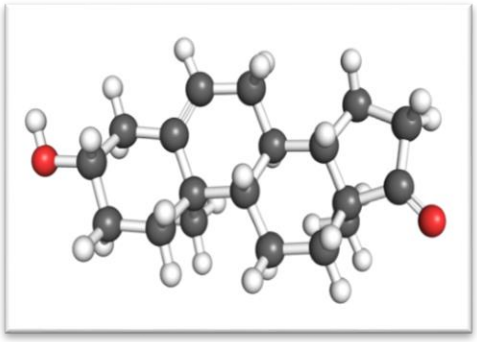


Renal Physiology (Control & Clinical)

Renal Control of Electrolytes

-Aldosterone stimulates sodium reabsorption and potassium secretion in the distal convoluted tubule.



-Aldosterone secretion is stimulated directly by a rise in blood potassium and indirectly by a fall in blood sodium.

-Aldosterone stimulates the secretion of H+, as well as potassium, into the filtrate in exchange for sodium

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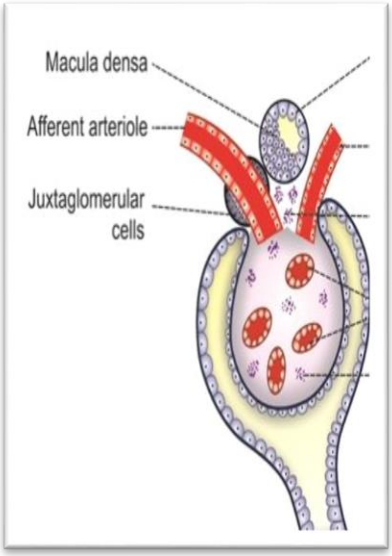
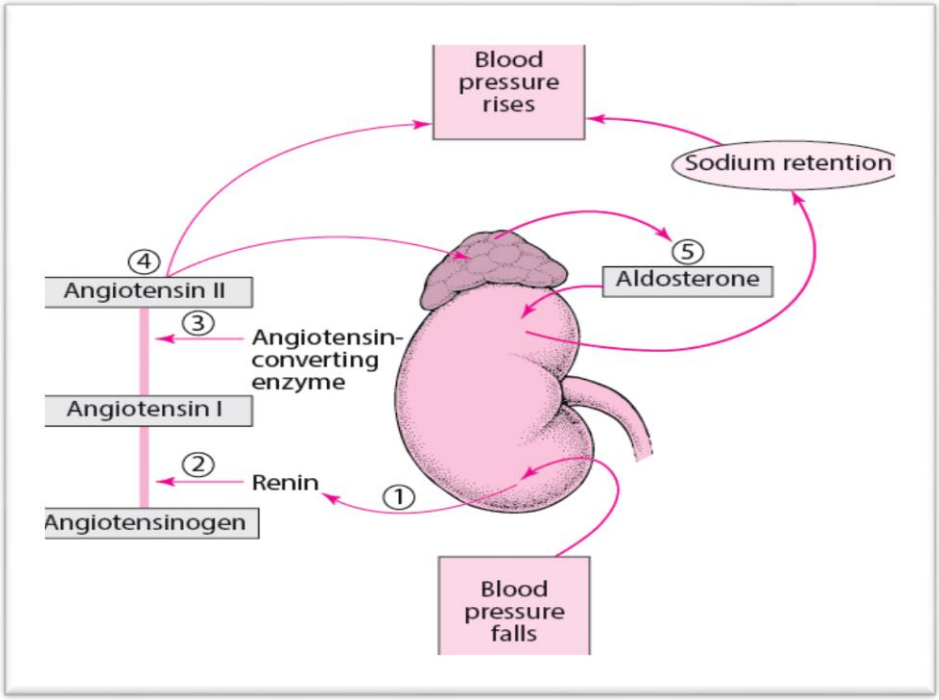
Renin-Angiotensin System
Aldosterone Secretion Mechanism

1. Decreased blood flow through the kidneys stimulates the secretion of the enzyme renin from the juxtaglomerular apparatus.
2. Renin catalyzes the formation of angiotensin I, which is then converted to angiotensin II.
3. Angiotensin II stimulates the adrenal cortex to secrete aldosterone.





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Renal Control of Acid-Base Balance

The nephrons filter bicarbonate and reabsorb the amount required to maintain acid-base balance.

- Reabsorption of bicarbonate, however, is indirect.

1. Filtered bicarbonate combines with H^+ to form carbonic acid in the filtrate.
2. Carbonic anhydrase in the membranes of microvilli in the tubules catalyzes the conversion of carbonic acid to carbon dioxide and water.
3. Carbon dioxide is reabsorbed and converted in either the tubule cells or the red blood cells to carbonic acid, which dissociates to bicarbonate and H^+.
4. In addition to reabsorbing bicarbonate, the nephrons filter and secrete H+, which is excreted in the urine