Renal Physiology

The kidneys have several functions including the following:

[1] Kidneys regulate water and electrolytes balance

[2] Kidneys responsible for excretion of metabolic waste products like urea

[3] Kidneys play essential role in regulation of arterial

[4] Kidneys contribute to acid-base regulation

[5] Kidneys responsible for regulation of erythrocyte production from the bone marrow

[6] Kidneys regulate 1,25- dihydroxy vit D_3 production which is essential in regulation of Ca and phosphate.

Anatomy and function of the kidney

The kidney consists of: **[A] Nephron. [B] Blood vessels. [C] Nerves**

(A) Nephron: It is the basic functional unit of the kidney and capable of forming urine by itself. There are about 1 million nephrons in each kidney in human.

[1] Bowman`s capsule: It is the invaginated blind end of the tubule that encased the **glomerulus**

The membrane of the glomerular capillaries is called the **glomerular membrane**.

[2] Proximal convoluted tubules:

Reabsorption in the proximal tubule is of the filtered Na and water, almost all the filtered glucose, amino acids, organic acids, and small amount of protein which is present, as well as much of the K, Ca, phosphate and urea are reabsorbed in the proximal tubule.

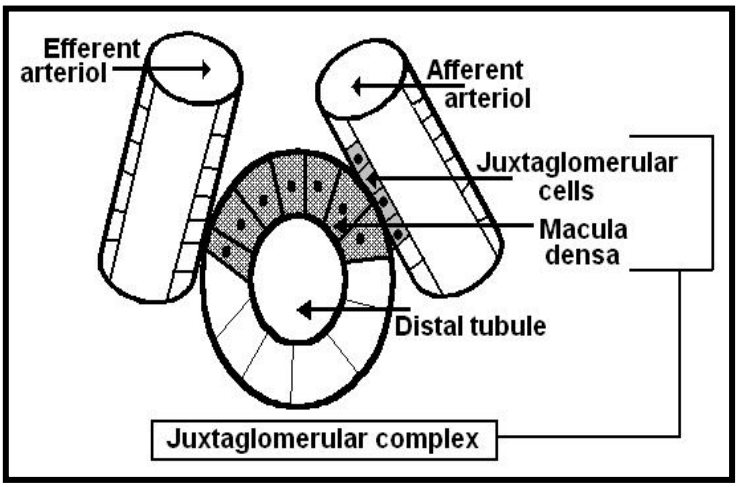
[3] Loops of Henle: The nephrons with their glomeruli located in the outer portion of the renal cortex have short loops of Henle **(cortical nephrons, 70%),** where as those with glomeruli in the juxtamedullary region of the cortex (**juxtamedullary nephrons, 30%)** have long loop extending down into medullary pyramids.

The thin descending segment of the loop of Henle They are highly permeable to water but much less permeable to urea, sodium and most other ions

The thin ascending segment of the loop of Henle are far less permeable to water but more permeable to urea than is the descending portion.

The thick ascending segment of the loop of Henle: the cells adapted for strong active transport of sodium, potassium, and chloride ions. On the other hand, the thick segment is almost entirely impermeable to both water and urea. the diluting segment.

Macula densa. The specialized smooth muscle cells of the afferent arterioles that come in contact with the macula densa are called **juxtaglomerular cells** (JG cells) which contain renin granules. Macula densa and JG cells plus few granulated cells between them are collectively known as **juxtaglomerular complex or apparatus** which has a dense adrenergic neural innervation.



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[4] Distal convoluted tubule: They lie in the renal cortex.

[5] Collecting tubules and ducts:

- Its permeability to water is under the control of ADH similar to the cortical collecting duct.
- It is permeable to urea (unlike the cortical collecting duct).
- It is capable of secreting H ions against concentration gradient.

(B) Blood vessels: Interlobular artery ➔ arcuate artery ➔ Afferent arteriole ➔ branching capillaries in Bowman`s capsule (glomerulus) ➔Efferent arterioles ➔ branching around the tubules so called **(Peritubular capillaries**) ➔ arcuate vein ➔ interlobular vein.

[C] Nerve supply: The kidney has a rich adrenergic sympathetic nerve supply distributed to the:

[A] Vascular smooth muscle to cause vasoconstriction.

[B] Juxtaglomerular cells to cause renin secretion.

[C] Tubular cells to stimulate Na and water reabsorption.

Glomerular function:

Glomerular filtration rate (GFR): It is the fluid that filtrate through the glomerulus into Bowman`s capsule each minute in all nephrons of both kidneys which is about **125 ml/min** or **180 L/day**

The selectivity of the glomerular membrane depends on:

[1] Size of the molecules:

[2] The electrical charges of the molecules:

Factors affect the rate of reabsorption of fluid: These factors play a significant role in determining the rate of fluid volume excretion (i.e. the urine).

[1] Osmotic diuresis:

[2] Plasma colloid osmotic pressure:

[3] Sympathetic stimulation:.

[4] Arterial pressure:

[5] Hormonal control:

Aldosterone:

increase Na reabsorption and to increase K secretion.

Angiotensin II: [1] It stimulates aldosterone secretion, which in turn increases Na and water reabsorption. [2] It constricts the efferent arterioles and consequently increases Na and water reabsorption.

[3] It act directly especially on the proximal tubule to increase Na and water reabsorption

Atrial natriuretic peptide: It inhibits the reabsorption of Na and water by the renal tubules

Parathyroid hormone: It increases the reabsorption of Ca and Mg ions

Diuretics that increase flow rate through the distal tubule (such as thiazide and loop diuretics) cause dilution of the luminal K concentration, increasing the driving force (concentration gradient between the tubular fluid and tubular cell) for K secretion. As a result of increased K secretion, these diuretics cause hypokalaemia. In contrast, K-sparing diuretics either antagonize the action of aldosterone (such as spironolactone) or act directly on the principal cells (such as triameterene and amiloride) to decrease K secretion and cause hyperkalaemia.

Micturition: Is the process by which the urinay bladder empties when it becomes filled.

The micturition reflex: As the bladder fills, it stretches the bladder wall, thus stimulating stretch receptors especially in the bladder neck. The first urge to void is felt at a bladder volume of about 150 ml, and a marked sense of fullness at about 300-400 ml. Then, sensory signals are conducted to the sacral segments of the spinal cord through the pelvic nerves and then back again to the bladder through the parasympathetic fibers in these same nerves initiating micturition contraction of the detrusor muscles. Once a micturition reflex begins, it is self-regenerative and the high pressure inside the bladder forces the bladder neck to open against its tonic contraction. Stretching the bladder neck exacerbates the intensity of the micturition reflex and also activates another reflex. This reflex passes to the sacral portion of the spinal cord and then back through the pudendal nerve to the external sphincter to inhibit it. If this inhibition is more potent than the voluntary constrictor signals from the brain, then urination will occur. Then after a few seconds to more than a minute, the reflex begins to fatigue allowing rapid reduction in bladder contraction.