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Medicine & Surgery

Renal Physiology Assignment

**Questions**

1. Discuss the role of kidney in glucose homeostasis?
2. Discuss the process of micturition?
3. Explain juxtaglomerular apparatus?
4. Discuss the role of kidney in regulation of blood pressure?
5. Discuss the role of kidney in calcium homeostasis?
6. The kidneys synthesize glucose from amino acids and other precursors during prolonged fasting, a process referred to as gluconeogenesis. The kidneys’ ability to add glucose to the blood during prolonged periods of fasting rivals that of the liver. Glucose is completely reabsorbed in the proximal convoluted tubule. It is transported by secondary active transport (sodium cotransport) mechanism, Glucose and sodium bind to a common carrier protein in the luminal membrane of tubular epithelium and enter the cell. The carrier protein is called sodium-dependent glucose cotransporter 2. From the tubular cell glucose is transported into medullary interstitium by another carrier protein called glucose transporter 2. The renal threshold for glucose is 180mg/dl in venous blood. When the blood level reaches 180mg/dl glucose is not reabsorbed completely and appears in urine.
7. Micturition is a process by which urine is voided from the urinary bladder. It is a reflex process. Micturition reflex is the reflex by which micturition occurs. This reflex is elicited by the stimulation of stretch receptors situated on the wall of urinary bladder and urethra. When 300 to 400ml of urine is collected in the bladder, intravesical pressure increases. This stretches the wall of the bladder resulting in stimulation of stretch receptors and generation of sensory impulses.

Sensory impulses from the receptors reach the sacral segments of spinal cord via the sensory fibers of pelvic nerve. Motor impulses produced in spinal cord, travel through motor fibers of pelvic nerve towards bladder and internal sphincter. These motor impulses, cause contraction of detrusor muscle and relaxation of internal sphincter so that, urine enters the urethra from the bladder. Once a micturition reflex begins, it is self-regenerative i.e. the initial contraction of bladder and urethra further activates the receptors to cause still further increase in reflex contraction of the bladder. The cycle continues repeatedly until the force of contraction of bladder reaches the maximum and urine is voided out completely. During micturition, the flow of urine is facilitated by the increase in the abdominal pressure due to the voluntary contraction of abdominal muscles.

Centers in the midbrain and cerebral cortex inhibit the micturition by suppressing the spinal micturition centers. Centers in pons facilitate micturition via spinal centers.



1. Juxtaglomerular apparatus is a specialized organ situated near the glomerulus of each nephron. The juxtaglomerular apparatus is formed by three different structures:

* Macula Densa
* Extraglomerular mesangial cells
* Juxtaglomerular cells
* *Macula Densa*- This is the end portion of thick ascending segment before it opens into distal convoluted tubule. It is situated between afferent and efferent arterioles of the same nephron. It is very close to afferent arteriole. Macula densa is formed by tightly packed cuboidal epithelial cells.
* *Extraglomerular mesangial cells*- They are situated in the triangular region bound by afferent arteriole, efferent arteriole and macula densa. These cells are also called agranular or lucid cells.

There is another type of mesangial cells situated between glomerular capillaries called glomerular mesangial or intraglomerular mesangial cells. The glomerular mesangial cells support the glomerular capillary loops by surrounding the capillaries in the form of a cellular network. These cells play an important role in regulating the glomerular filtration by their contractile property. Glomerular mesangial cells are phagocytic in nature. They secrete glomerular interstitial matrix, prostaglandins and cytokines.

* *Juxtaglomerular cells*- are specialized smooth muscles cells situated in the wall of afferent arteriole just before it enters the bowman capsule. These smooth muscle cells are mostly present in tunica media and tunica adventitia of the wall of the afferent arteriole. These cells are called granular cells because of the presence of secretory granules in their cytoplasm.

The primary function of juxtaglomerular apparatus is the secretion of hormones. It also regulates the glomerular blood flow and glomerular filtration rate.

The juxtaglomerular apparatus secretes renin and prostaglandin. Renin functions in reduction in arterial blood pressure, reduction in ECF volume, increases sympathetic activity. Prostaglandin decreases blood pressure by systemic vasodilation, diuresis and natriuresis.

The extraglomerular mesangial cells of juxtaglomerular apparatus secrete cytokines like interleukin-2 and tumor necrosis factor. Macula densa secretes thromboxane A2.

1. The kidneys play an important role in the long-term regulation of arterial blood pressure. They regulate arterial blood pressure by two ways

* By regulation of ECF volume: When blood pressure increases, kidneys excrete large amounts of water and salt, particularly sodium, by means of pressure diuresis and pressure natriuresis. Pressure diuresis is the excretion of large quantity of water in urine because of increased blood pressure, even a slight increase in blood pressure doubles the water excretion. Pressure natriuresis is the excretion of large quantity of sodium in urine. Because of diuresis and natriuresis, there is decrease in ECF volume and blood volume, which in turn brings the arterial blood pressure back to normal level. When blood pressure decreases, the reabsorption of water from renal tubules is increased. This in turn, increases ECF volume and cardiac output, resulting in restoration of blood pressure.
* Through renin-angiotensin mechanism: When blood pressure and ECF volume decrease, renin secretion from kidneys is increased. It converts angiotensinogen into angiotensin I. This is converted into angiotensin II by angiotensin-converting enzyme. The angiotensin II acts in two ways to restore the blood pressure.

It causes constriction of arterioles in the body so that the peripheral resistance is increased and blood pressure rises, in addition, angiotensin II causes constriction of afferent arterioles in the kidneys, so that glomerular filtration reduces. This results in retention of water and salts, increases ECF volume to normal level. This in turn increases the blood pressure to normal level.

Angiotensin II stimulates the adrenal cortex to secrete aldosterone. This hormone increases reabsorption of sodium from renal tubules. Sodium reabsorption is followed by water reabsorption followed by increase in ECF volume and blood volume. It increases the blood pressure to normal level.

1. The kidneys play a role in the regulation of blood calcium level by activating 1,25-dihydroxycholecalciferl into vitamin D. Vitamin D is necessary for the absorption of calcium from intestine. Calcitriol is a steroid hormone synthesized in the kidney. It is the activated form of vitamin D. Its main action is to increase the blood calcium level by increasing the calcium absorption from the small intestine.