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**COURSE TITLE: RENAL PHYSIOLOGY, BODY FLUIDS AND TEMPERATURE REGULATION**

**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.

ROLE OF KIDNEY IN GLUCOSE HOMEOSTASIS

Glucose homeostasis involves the maintenance and regulation of glucose circulation and uptake by body systems. Level of blood glucose can be regulated via gluconeogenesis and glycogenolysis, which could be controlled by the kidney. Gluconeogenesis involves the formation of glucose from non glucose precursors like, amino acids, glycerol and lactate. Glycogenolysis involves the breakdown of stored glycogen to form glucose needed for energy by body systems. The involvement of the kidney in the regulation of glucose homeostasis aids in the release of glucose free urine. The process of renal glucose reabsorption is mediated by active sodium-coupled glucose co transporters and passive glucose transporters.

The kidneys are capable of synthesizing and secreting many important hormones such as; rennin, prostaglandins, kinins and erythropoietin, thus, they are involved in a wide variety of metabolism such as; activation of vitamin D3, gluconeogenesis. The kidney is perceived as two organs with regards to the utilization of glucose as glucose utilization occurs in the renal medulla and glucose release in the renal cortex. This is as a result of differences in the distribution of various enzymes along the nephron. Cells in the renal medulla have glucose phosphorylating and glycolytic enzyme activity, hence, they can phosphorylate and accumulate glycogen, which is the storage form of excess glucose. But, the cells of the renal medulla cannot release free glucose into circulation because, they do not possess glucose-6-phosphatse and gluconeogenic enzymes like the cells of the renal cortex. Therefore, when there is a state of hypoglycemia, the renal cortex is stimulated for the release of glucose via glycogenolysis and in a state of hyperglycemia, the renal medulla is stimulated for the uptake and accumulation of glucose as glycogen. The renal contribution for total body glucose release post absorptive state is approximately 20% and the renal contribution to total body gluconeogenesis is approximately 40%.

In addition, the kidney also regulates glucose homeostasis via filtering and reabsorbing glucose. The glomeruli filter from plasma approximately 180 grams of glucose per day are all absorbed through glucose transporter proteins that are present in the cell membranes within the proximal tubes. The maximum capacity for glucose reabsorption by the proximal tubules ranges from 260 to 350mg/min/1.73metre squared and if this capacity is exceeded, glucose then appears in the urine (glucosuria).

MICTURITION

Micturition is the release of urine from the urinary bladder through the urethra to the outside body. It is another term for urination. Micturition is the urinary system’s method of excretion. The process of micturition is regulated by the nervous system and muscles of the bladder and urethra. About 350-400ml of urine can be stored in the urinary bladder before excretion. There are two stages involved in the process of micturition, they are, the resting or filling stage and the voiding stage.

In the resting or filling stage, the urine is transported from the kidneys to the bladder via the ureters, which are thin muscular tubes that enter the urinary bladder obliquely. The oblique placement of the ureters in the bladder aid in preventing the reflux of the urine into the ureters from the bladder since, there is no sphincter or muscle guarding the opening of the ureters into the urinary bladder. The major muscle of the urinary bladder, which is the detrusor muscle relaxes and allows the bladder to distend and accommodate the urine until it is time for the voiding stage of micturition to occur.

In the voiding stage, the urinary bladder and the urethra are the organs involved. The detrusor muscle of the urinary bladder begins to contract once the bladder’s storage capacity is reached. The urethra on the other hand, is controlled by two sets of muscles, the internal urethral sphincter and the external urethral sphincter. These muscles of the urethra begin to relax to receive and excrete the urine. The internal urethral sphincter relaxes to receive the urine from the urinary bladder and the external urethral sphincter is stimulated to relax, thus releasing the urine to the outside body.

Within the nervous system, the micturition process is controlled by the autonomous nervous system and the somatic system, once the urinary bladder reaches its maximum capacity of storage, the stretch receptors in the walls of the bladder send impulses through the pelvic nerve to the brain via the spinal cord. The micturition reflex is then generated at the level of the spinal cord after it receives reflexes from the pontine region of the brain. Once the bladder and urethra receive signals from the brain to empty the bladder, the two sphincters relax and the detrusor muscle causes the contraction of the bladder. In addition, the muscles of the abdomen put pressure on the bladder wall and with attainment of a suitable position there is complete emptying of the bladder.

JUXTAGLOMERULAR APPARATUS

Juxtaglomerular apparatus is a specialized organ situated near the glomerulus of each nephron. It is formed by three different structures which are the macula densa, the extraglomerular mesangial cells and the juxtaglomerular cells.

The macula densa is the end portion of the thick ascending segment before it opens into the distal convoluted tubule. It is located between afferent and efferent arterioles of the same nephron where it is found. It lies very close to the afferent arteriole. It is formed majorly by tightly packed cuboidal epithelial cells. The extraglomerular mesangial cells are located in the triangular region bound by afferent arteriole, efferent arteriole and macula densa. These cells are also called the lacis cells. There are also some other cells known as the glomerular mesangial cells located in the glomerular capillaries. They support the glomerular capillary loops by surrounding the capillaries in the form of a cellular network. They also play an important role in the regulation of glomerular filtration by their contractile property.

The juxtaglomerular cells are specialized smooth muscle cells situated in the wall of the afferent arteriole just before it enters the Bowman’s capsule. They are mostly present in tunica media and adventitia of the wall of the afferent arteriole. They can also be referred to as granular cells because of the presence of secretory granules in their cytoplasm. They form a thick cuff called the polar cushion around the afferent arteriole before they enter the Bowman’s capsule.

The primary function of the juxtaglomeular apparatus, is the secretion of hormones. They also function in the regulation of glomerular blood flow and glomerular filtration rate. It secretes majorly two hormones the rennin and prostaglandin. The extraglomerular mesangial cells secrete cytokines while the macula densa secretes thromboxane A2. The macula densa of the juxtaglomerular apparatus plays an important role in the feedback mechanism called the tubuloglomerular mechanism, which regulates the renal blood flow.

ROLE OF KIDNEY IN REGULATION OF BLOOD PRESSURE

The kidney plays an important role in regulation of blood pressure and its regulation is long term. When blood pressure alters slowly in several days, months or years, the nervous mechanism of regulation adapts to the altered pressure and looses the sensitivity for the changes. In such cases, the renal mechanism operates efficiently to regulate the blood pressure. The kidney regulates arterial blood pressure by two ways; by regulation of ECF volume and through rennin-angiotensin mechanism.

By regulation of ECF volume, when the blood pressure increases, the kidney excretes large amount of water and salt by means of pressure dieresis and pressure natriuresis. Pressure dieresis is the excretion of large quantity of water in urine because increased blood pressure and pressure natriuresis is the excretion of large quantity of sodium. Due to the dieresis and natriuresis, there is a decrease in blood volume and ECF volume which, in turn, brings the arterial blood pressure back to normal level. On the other hand, when blood pressure decreases, there would be increased reabsorption of water in the renal tubules. This increase reabsorption of water then, increases ECF volume and blood volume and cardiac output. Therefore, the arterial blood pressure is restored.

Through the rennin-angiotensin mechanism, when blood pressure and ECF volume decreases, rennin secretion from the kidneys is then increased. The hormone converts angitensinogen to angotensin I. The angiotensin I is in turn converted to angiotensin II by the angiotensin converting enzyme. The angiotensin then acts to restore blood pressure. It could be by causing constriction of arterioles in the body so that, peripheral resistance is increased. It also cause constriction of afferent arterioles of the kidney so that glomerular filtration reduces. This retention of water and salt then increases ECF volume and blood volume, which in turn increases blood pressure to the normal level. Angiotensin II also stimulates the secretion of aldosterone by the adrenal cortex . aldosterone increases the reabsorption of sodium from renal tubules. The sodium reabsorption is followed by water reabsorption, which results in increased ECF volume and blood volume. It then increases the blood pressure to normal level.

ROLE OF KIDNEY IN CALCIUM HOMEOSTASIS

Blood calcium level is regulated mainly by three hormones which are, the parathormone, 1,25-dihydroxycholecalciferol and calcitonin. The parathormones is secreted by parathyroid gland to increase blood calcium level. Calcitonin is secreted by the parafollicular cells of the thyroid gland and it reduces blood calcium level. The 1,25-dihydroxycholecalciferol hormone is synthesized in the kidney. It is the activated form of vitamin D and its main action is to increase blood calcium level by increasing the calcium absorption from the intestine.

When the calcium level is decreased, the kidney secretes the hormone which is released into the intestine to stimulate the absorption of calcium which normalizes the blood calcium level.