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**MEDICINE AND HEALTH SCIENCES**

**MEDICINE AND SURGERY**

**PHYSIOLOGY**

**PHS 303**

**ANSWERS**

1. The major part played by the kidney in glucose homeostasis is **glucose reabsorption**. The kidneys’ contributions to maintaining glucose homeostasis are significant and include such functions as:

* release of glucose into the circulation via gluconeogenesis
* uptake of glucose from the circulation to satisfy their energy needs
* reabsorption of glucose at the level of the proximal tubule.

Renal release of glucose into the circulation is the result of glycogenolysis and gluconeogenesis, respectively involving the breaking down and formation of glucose-6-phosphate from precursors (eg, lactate, glycerol, amino acids). With regard to renal reabsorption of glucose, the kidneys normally retrieve as much glucose as possible, rendering the urine virtually glucose free. The glomeruli filter from plasma approximately 180 grams of D-glucose per day, all of which is reabsorbed through glucose transporter proteins that are present in cell membranes within the proximal tubules. If the capacity of these transporters is exceeded, glucose appears in the urine. The process of renal glucose reabsorption is mediated by active (sodium-coupled glucose cotransporters) and passive (glucose transporters) transporters. In hyperglycemia, the kidneys may play an exacerbating role by reabsorbing excess glucose, ultimately contributing to chronic hyperglycemia, which in turn contributes to chronic glycemic burden and the risk of microvascular consequences.

2) **Micturition** is a process where urine is expelled from the body. It is brought about by reflex contraction of a special muscle called the detrusor muscle after voluntary relaxation of the sphincter muscle.

Micturition process consists of two phases:

* Storage phase
* Voiding phase

**Storage Phase**

The urinary bladder is a balloon-shaped, hollow, muscular, organ that acts as the storage organ for urine. The urinary bladder in a healthy urinary system can store up to 16 ounces of urine for 2 to 5 hours easily. The circular sphincter muscles prevent leakage of urine. They close tightly around the opening of the bladder into the tube (urethra) that allows the passage of urine outside the body.

**Voiding Phase**

When the bladder is filled with urine, the nerves in it are triggered, which in turn stimulates the need to urinate. The brain signals urinary bladder to contract. The receptors of the urinary bladder send a signal to the central nervous system, in response to which the nervous system sends a signal that incites the contraction of the urinary bladder. Through the urinary opening at the urethra, the urine is eliminated, and the process is called micturition. The neural mechanism involved is called the micturition reflex.

3) **Juxtaglomerular Apparatus**

Juxtaglomerular apparatus is a specialized organ situated near the glomerulus of each nephron.The juxtaglomerular apparatus is a specialized structure formed by the distal convoluted tubule and the glomerular afferent arteriole. It is located near the vascular pole of the glomerulus and its main function is to regulate blood pressure and the filtration rate of the glomerulus. STRUCTURE: Its formed by three structures

* Macula densa
* Extraglomerular mesangial cells
* Juxtaglomerular cells

MACULA DENSA: Is the end portion of thick ascending segment before it opens into the distal convoluted tubule. It is situated between afferent and efferent arterioles of the nephron. It is formed by tightly packed cuboidal epithelial cells

EXTRAGLOMERULAR MESANGIAL CELLS: they are situated in triangular region bound by afferent arteriole, efferent arteriole and macula densa. The cells are also called agranular cells, lacis cells or goormaghtigh cells

JUXTAGLOMERULAR CELLS: They are specialized smooth muscle cells situated in the wall of afferent arteriole just before it enter the bowman capsule. The smooth muscle cells are mostly present in tunica media and tunica adventitia of the wall of the afferent arteriole. They are also called granular cells because of the presence of secretory granules in their cytoplasm.

**FUNCTIONS**

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

**MACULA DENSA**: Cells in the macula densa respond to changes in the sodium chloride levels in the distal tubule of the nephron via the tubuloglomerula feedback loop (TGF). An increase in the salt concentration causes several cell signals to eventually cause the adjacent afferent arteriole to constrict, this decreases the amount of blood coming from the afferent arterioles to the glomerular capillaries and therefore decreases the amount of fluid that goes from the glomerular capillaries into the Bowman`s space. When there is decrease in the sodium concentration, less sodium is reabsorbed in the Macula densa cells. The cells increase the production of nitric oxide and prostaglandins to vasolidate the afferent arteriole to increase renin release.

**EXTRAGLOMERULAR MESANGIAL CELLS:** These cells have a contractile property similar to vascular smooth muscles and thus play a role in regulating “GFR” by altering the vessel diameter. Renin is also found in these cells.

**JUXTAGLOMERULAR CELLS:** These cells produce renin. They secrete renin in response to:

* stimulation of the beta-1 adrenergic receptor
* Decrease in renal perfusion pressure (detected directly by the granular cells).
* Decrease in NaCL concentration at the macula densa, often due to a decrease in glomerular filtration rate

4) Increased pressure has a direct effect on the kidney

The formula:

Q = (PA - PE) ÷ R

Q = Flow, PA = Pressure in afferent arteriole, PE = Pressure in efferent arteriole, R = Resistance

Three mechanisms of Renal Regulation:

* Pressure Diuresis
* As arteriolar blood pressure increases, so flow through the kidneys also increases - see above formula
* This increases filtration rate
* This increases urinary output
* Pressure Natriuresis
* If renal perfusion pressure is increased then sodium excretion increases, i.e. sodium excretion increases when blood pressure increases
* If more sodium is excreted less water is reabsorbed therefore the ECF volume decreases and blood pressure decreases.
* The actual mechanism is not clear but it is thought to involve a direct effect of the pressure on the renal interstitium.
* Renin-Angiotensin-Aldosterone System
* Specialized cells in the distal tubule called the macula densa sense the concentration of sodium and chloride.
* If blood pressure falls there is a reduction in concentration of sodium and chloride in the distal tubule which is sensed by the macula densa.
* The macula densa releases prostaglandins which act on the juxtaglomerular apparatus which releases renin into the bloodstream.
* The drop in blood pressure is also detected by baroreceptors in the aortic arch, carotid sinus and the afferent renal arteriole which stimulates renin release by the juxtaglomerular apparatus.
* Renin cleaves angiotensinogen into angiotensin 1 which in turn is cleaved by Angiotensin Converting Enzyme (ACE) into angiotensin 2.
* Angiotensin 2 is a potent vasoconstrictor and also stimulates the adrenal cortex to release aldosterone.
* Aldosterone acts on the distal tubules and collecting ducts in the kidney causing retention of sodium and water.
* Blood pressure increases.

5) The kidney is critically important in calcium homeostasis. Under normal blood calcium concentrations, almost all of the calcium that enters glomerular filtrate is reabsorbed from the tubular system back into blood, which preserves blood calcium levels. If tubular reabsorption of calcium decreases, calcium is lost by excretion into urine.