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**Renal physiology assignment**

**Answer to question one**

**Role of the kidney in glucose homeostasis.**

The kidney helps in maintaining glucose homeostasis through three different mechanisms:

1) Gluconeogenesis

2) uptake of glucose into circulation to satisfy its energy needs.

3) Glucose reabsorption

1) **Gluconeogenesis:** After a 16hour overnight fast, approximately 10 umol/(kg/min) of glucose is released into the circulation. The renal cortex contains gluconeogenic enzymes and it can synthesize glucose-6-phosphate from precursors ( lactate,glutamine,glycerol and alanine). Because I contains glucose-6-phospatase, it is able to release glucose into the blood stream.

The liver and the kidney are the only organs that can perform Gluconeogenesis. Therefore, after an overnight fast, the liver produces 75-80% of glucose releases into the circulation while the remaining 20-25% is derived from the kidneys.

**Glucose reabsorption:** the kidneys contribute to glucose homeostasis by filtering and reabsorbing glucose. Approximately 180 grams of glucose are filtered by the glomeruli from plasma daily. The process of renal glucose reabsorption is mediated by active ( sodium-coupled glucose cotransporters) and passive ( glucose transporters) transporters.

Glucose transporters proteins are present in the cell membranes within the proximal tubules.

These glucose transporters have a limited capacity of reabsorption, if the capacity is exceeded, glucose appears in the urine.

**Answer to question two**

**Process of micturition.**

Micturiction is the process by which urine is voided from the urinary bladder. However in grown up children and adults, it can be controlled voluntarily to some extent.

Between urinations, the detrusor muscle must be relaxed and the urethral sphincters remain closed due to;

• Sympathetic pathways from the upper lumbar region. These fibers relax the detrusor and excite the internal sphincter.

External sphincter contains skeletal muscle and innervation is from somatic motor fibers from upper sacral region.

200ml urine in bladder, stretch receptors in bladder walls sends signals to sacral spinal cord. Signals ascend to 2 area;

• Terminate at the inhibitory synapse of sympathetic neurons, this turns them off thus allowing urination.

• Micturiction center in the pons integrates information from the full bladder with other center of the brain like the amygdala and the cerebellum. So here is where urination can be prompted by fear or inhibited by the knowledge that it is inappropriate circumstances to urinate.

Signals return from micturiction center via recticulospinal tract to the detrusor muscle via the parasympathetic neurons. These are excitatory and stimulates the bladder to contract.

• The contraction further excites the stretch receptors and start positive feedback loop.

• Motor impulses causes contraction of detrusor muscle and relaxation of internal sphincter so that, urine enters the urethra from the bladder.

• Also, relaxes the internal urethral sphincter ( urine is voided unless inhibited by brain)

Once urine enters the urethra, the stretch receptors in the urethra are stimulated and send afferent impulses to spinal cord via pelvic nerve fibers. Now the impulses generated from the spinal centers inhibit the pudendal nerve.

Then the external urethral sphincter

• descending signals from the cerebral cortex travel via the corticospinal tracts to the sacral spinal cord and inhibits the somatic motor neurons so the external sphincter relaxes and micturition occurs.

• Voluntary component of micturition involves increase in abdominal pressure due to voluntary contraction of abdominal muscles. Also, if we must suppress the urge to urinate results in stretch receptors fatiguing and stop firing.

Also, if the bladder is not full and we want to urinate, we use the valsalva maneuver to compress the bladder and excite the stretch receptors.

**Answer to question three**

The juxtaglomerular Apparatus is a specialized organ situated near the glomerulus of each nephron ( juxta-near).

Juxtaglomerular Apparatus is formed by 3 different structures which are;

1) Macula densa

2) Extraglomerular Mesangial cells

3) Juxtaglomerular cells

**Macula densa**

It is the end portion of thick ascending segment before it opens into the distal convulated tubule. It is stimulated between the afferent and efferent arterioles of sand nephrons. It is very close to the afferent arteriole.

Macula densa plays an important role in the tubuloglomerular feedback mechanism. It also secretes thromboxane A2.

**Extraglomerular mesangial cells**

They are situated in the triangular portion bound by afferent arteriole, efferent arteriole and macula densa. They are also called agranular cells or lacis cells. They secrete prostaglandins and cytokines.

**Juxtaglomerular cells**

They are specialized smooth muscle cells situated in the walls of the afferent arteriole just before it enters the Bowman’s capsule. They are also called granular cells.

The juxtaglomerular Apparatus main function is the secretion of Hormones. It also regulates the glomerular blood flow and glomerular filtration rate. It secretes;

•Renin

• prostaglandins

The juxtaglomerular cells secrete renin . Renin is a peptide hormone with 340 amino acids. Along with angiotensin, Renin forms the Renin-angiotensin system which is a hormone that plays an important role in the maintenance of blood pressure.

Stimulants for renin are;

• Fall In arteial blood pressure

• Reduction in the ECF volume

• Increased sympathetic activity

• Decreased load of sodium and chloride in macula densa

Extraglomerular mesangial cells also secretes cytokines like interleukin-2 and tumor necrosis factor.

**Answer to question four**

Role of Kidney in regulation of blood pressure

The kidneys regulates blood pressure through the Renin-angiotensin system.

When blood pressure drops, the SNS stimulates the juxtaglomerular cells to produce Renin.

When renin is released into the blood, it acts on a specific plasma protein called angiotensinogen or renin substrate. It is an alpha-2 globulin. By the activity of renin, the angiotensinogen is converted into angiotensin 1. Angiotensin 1 is converted into angiotensin II by the activity of angiotensin-converting enzyme secretes by the lungs. Most of the conversion of angiotensin I to angiotensin II takes place in the lungs. Angiotensin II is the active form and acts on;

• **Blood vessels:** it increases arterial blood pressure by directly acting on the blood vessels and causing vasoconstriction. It is a potent constrictor of arterioles.

It increases blood pressure indirectly by increasing the release of noradrenaline from postganglionic sympathetic fibers. Noradrenaline is a general vasoconstrictor.

• **On Adrenal gland**: It stimulates Zona glomerulosa of adrenal cortex to secrete aldosterone. Aldosterone acts on the renal tubules and increases the retention of sodium which is responsible for elevation of blood pressure.

• **On the brain:** Angiotensin II inhibits the baroreceptor reflex and thereby indirectly increases the blood pressure.

**Answer to question five**

**Role of kidney in calcium homeostasis**

About 50% of plasma calcium (ionized and complex form; ultrafilterable fraction, excluding the protein bound form) is freely filtered through the renal glomerulus and 99% of the filtered calcium is reabsorbed along the renal tubules.

The excreted calcium in the urine is about 200mg per day in an adult person with average diet.

Several factors are involved in the regulation of calcium in renal tubules;

Parathyroid hormone and activated vitamin D enhance calcium reabsorption in the thick ascending limb, distal convulated tubule. Estrogen promotes calcium absorption in the distal convulated tubule.

The transport of calcium is by two pathways of transport;

• Paracellular

• Transcellular

Paracellular pathways are dependent on transepithelial electrochemical gradients and can be regulated by specialized Paracellular proteins called Claudins (claudin-16).

Transcellular pathway implies the presence of a tight epithelium and a three step transport with apical entry , transcytoplamic transport and basolateral extrusion mechanism.

The driving force is mainly provided by basolateral ca- or Na-k-ATPases.

In the proximal tubules, 60% of filtered calcium is reabsorbed by passive mechanism. In the thick ascending limb, 15% of calcium is reabsorbed by Paracellular diffusion through Paracellin (claudin -16).