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ASSIGNMENT TITLE: RENAL PHYSIOLOGY FOR MBBS STUDENT

ANSWER

1. Discuss the role of kidney in glucose homeostasis?

**ROLE OF KIDNEY IN GLUCOSE HOMEOSTASIS**

Along with the liver, the kidney has an important role to play in glucose homeostasis i.e. maintaining the normal range of plasma glucose concentration. The plasma glucose concentration is determined by amount of glucose synthesized and the one removed from circulation and metabolized. The concentration must be maintained with a normal narrow range despite the wide daily fluctuations in glucose ingested and glucose expenditure in various tissues. The kidneys are therefore involved in glucose homeostasis via three different mechanisms; GLUCONEOGENESIS, GLYCOGENOLYSIS and RENAL GLUCOSE FILTRATION AND REABSORPTION. Renal release of glucose is as a result of GLYCOGENOLYSIS and GLUCONEOGENESIS in the renal cortex (due to presence of enzyme Glucose-6-phosphatase) involving the formation of glucose-6-phosphate from precursors e.g. Glycogen and Lactate, and subsequent hydrolysis into free glucose. With regards to RENAL REABSORPTION AND FILTRATION of glucose, the kidneys normally retrieve as much glucose as possible through glucose transporters(Passive) present at the cell membranes of the proximal tubules and sodium-glucose cotransporters(Active), rendering urine virtually glucose free. The maximum capacity of these transporters is known as the TUBULAR MAXIMUM OF GLUCOSE (TMG) which ranges from 260-350 mg/min in healthy adults and children. If the capacity of these transporters are exceeded, glucose appears in urine (GLUCOSURIA).

1. Discuss the process of micturition?

**MICTURITION**

Micturition/Urination is the process of expelling urine from the bladder. It is also known as VOIDING/EMPTYING OF THE BLADDER. The excretory in humans consist of a pair of kidneys, 2 ureters, a bladder, and the urethra. The kidney filters urine which is then transported to the bladder via the ureters to be stored till its expulsion via the urethra, due to the ureters’ oblique positioning, back flow of urine is prevented. The urinary bladder can hold up to 350-400ml of urine before it’s expelled. The process of micturition is regulated by the following:

* Nervous system
* Muscles of the bladder and urethra

The bladder has two distinct stages:

* Filling stage
* Voiding stage

During the filling stage, urine is transported from the kidney to the bladder via the ureters and during this stage, the DETRUSOR MUSCLE (The main muscle of the urinary bladder) is relaxed, which both sphincters of the urethra are contracted, allowing the bladder to distend and accommodate more urine.

During the voiding stage, both urinary bladder and urethra come into play. As mentioned earlier the process of micturition is governed by two systems; nervous and muscular system. So once the urinary bladder reaches its maximum capacity, the stretch receptors on the wall of the urinary bladder send impulse through pelvic nerve to the brain via the spinal cord. Micturition reflex is ultimately generated at the level of the spinal cord after it receives impulses from the pontine region in the brain. Once the bladder and urethra receives the impulse to empty, the two sphincters (internal and external) relax and detrusor muscle contacts, resulting in the contraction of the bladder and expulsion of urine. Alongside these muscles, muscles of the abdomen also play an important role by putting pressure on the bladder wall leading to the complete emptying of the bladder.

1. Explain juxtaglomerular apparatus?

**JUXTAGLOMERULAR APPARATUS**

Juxtaglomerular apparatus is formed by distal convoluted tubule and the glomerular afferent arteriole located near the vascular pole of the glomerulus.

FUNCTION:

* Regulation of blood pressure
* Regulation of glomerular filtration rate

Three different cells make the juxtaglomerular apparatus and they include:

* Juxtaglomerular cells
* External/Extra glomerular mesangial cells/Lacis cells
* Macula densa

JUXTAGLOMERULAR CELLS: Modified smooth muscle cells, of the afferent arteriole that regulates Renin-Angiotensin-Aldosterone system, by secreting renin when blood pressure falls in the arterioles and then this renin increases the blood pressure via the Renin-Angiotensin-Aldosterone system.

EXTERNAL/ EXTRA GLOMERULAR MESANGIAL CELLS (LACIS CELLS): These cells are closer to the macula densa, secretes prostaglandins, a vasodilator involved in renal regulation.

MACULA DENSA: Collection of specialized cells of the distal convoluted tubule, that detects sodium concentration of fluid in the tubule, regulating fluid osmolarity in the distal convoluted tubule. In response to increase in sodium, macula densa triggers the contraction of afferent arteriole, reducing flow of blood into the glomerulus and the glomerular filtration rate.

1. Discuss the role of kidney in regulation of blood pressure?

**ROLE OF KIDNEYS IN BLOOD PRESSURE REGULATION**

Specialized cells called the MACULA DENSA, senses sodium in filtrates while the JUXTAGLOMERULAR CELLS (Arterial cells) sense blood pressure. So when the blood pressure drops, the amount of filtered sodium also drops. The juxtaglomerular cells can sense the drop in blood pressure and the decrease in sodium concentration is relayed to them by the macula densa, stimulating the juxtaglomerular cells to produce RENIN, activating the RENIN-ANGIOTENSIN-ALDOSTERONE SYSTEM.

The renin secreted converts a proprotein, ANGIOTENSINOGEN to ANGIOTENSIN-I. ANGIOTENSIN-I is then converted to ANGIOTENSIN-II by ANGIOTENSIN CONVERTING ENZYME (in the lungs). ANGIOTENSIN-II then performs the following functions that helps return the blood pressure back to normal and they include:

* It contracts blood vessels, increasing the total peripheral resistance ultimately increasing blood pressure.
* It stimulates the adrenal gland to produce ALDOSTERONE, which then acts on the renal tubules to cause reabsorption of the electrolytes especially sodium, increasing blood volume which increases venous return and ultimately leads to the increase in cardiac output.
* It stimulates thirst centers, increasing intake of water which increases blood volume.
* It stimulates release of Antidiuretic hormone (Vasopressin) from the pituitary gland which acts on the collecting ducts to absorb water, increasing blood volume, venous return and ultimately cardiac output.

1. Discuss the role of kidney in calcium homeostasis?

**ROLE OF KIDNEY IN CALCIUM HOMEOSTASIS**

Maintenance of calcium homeostasis is very important because calcium is a main component of bony skeleton and serves as the intracellular and extracellular messengers in various cellular events such as neuronal network, immune response, muscle contraction, hormonal secretion. Maintaining the plasma/extracellular calcium concentration within a narrow range of 8.5-10.5 mg/dl Is very important for calcium homeostasis, which is achieved by the coordinated action of parathyroid hormone, vitamin D3, calcitonin, ionized calcium itself. The kidney plays a role in this process by fine regulation of calcium excretion. More than 95% of calcium is reabsorbed through the renal tubules. In the proximal convoluted tubule, 60% of filtered calcium is reabsorbed via PASSIVE MECHANISM. In the thick ascending limb, 15% of filtered calcium is reabsorbed by PARACELLULAR DIFFUSION through PARACELLIN-1 (CLAUDIN-16). The calcium sensing receptor senses changes in ionized calcium and lowers calcium reabsorption independent to parathyroid hormone and vitamin D3. The fine regulation of calcium excretion occurs in the distal convoluted and connecting tubules despite the fact that only 10-15% of filtered calcium is reabsorbed there. Transient receptor potential vanilloid (TRPV) 5 and 6 in the apical membrane act as main portal of entry, Calbindin-D28k then delivers the calcium in the cytoplasm and then the sodium/calcium exchanger (NCX1) and plasma membrane calcium-ATPase in the basolateral membrane serves as an exit.