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DEPARTMENT: MEDICINE AND SURGERY

COURSE: RENAL PHYSIOLOGY

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ASSIGNMENT

1. **Juxtaglomerular Apparatus**

This is also called JUXTAGLOMERULAR COMPLEX. It is a structure in the kidney that regulates the function of each nephron, the functional units of the kidney.

<u>Function of the juxtaglomerular apparatus</u>

- It regulates the blood pressure and filtration rate of the glomerulus.

<u>Structure of the juxtaglomerular apparatus</u>

The juxtaglomerular apparatus is part of the kidneys nephron and next to the glomerulus. It is found between the afferent arterioles and the distal convoluted tubule of the same nephron. This location is critical to its function in regulating renal blood flow and glomerular filtration rate.

The juxtaglomerular apparatus in made up of 3 cell types;

a) <u>Macula Densa;</u> a part of the distal convoluted tubule of the same nephron.
b) <u>Juxtaglomerular Cells/ Granular Cells;</u> secrete renin
c) <u>Extraglomerular Mesangial Cells</u>

Juxtaglomerular Cells/ Granular Cells

They produce renin. These cells are similar to epithelium cells and are located in the Tunica Media of the afferent arterioles as they enter the glomeruli. They are activated by prostaglandins released from the macula densa cells. The renin produced are secreted in response to;

- Stimulation of the beta-1 adrenergic receptor
- Decrease in renal perfusion pressure (detected by the granular cells)
- Decrease in NaCl concentration at the macula densa, often due to the glomerular filtration rate.
  Baroreceptors found in the arterioles trigger renin secretion if there's a fall in blood pressure in the arterioles. Activation of the sympathetic nervous system can also stimulate renin release trough the activation of beta-1 receptors.

Extraglomerular Mesangial Cells

This is located between the afferent and efferent arterioles and the glomerular capillaries. It is also known as **Lacis Cells** or **Goormaghtigh Cells**. These pale staining, renin containing cells are located just outside the glomerulus, near the vascular pole. They are a type of smooth muscle cell, and although their function is yet to be fully clarified, they play a role in autoregulation of blood flow to the kidney and regulation of systemic blood pressure through the renin-angiotensin system.

Macula Densa

This is an area of closely packed specialized cells lining the wall of the distal convoluted tubule, at the point where the thick ascending limb of the loop of Henle meets the distal convoluted tubule. The macula densa is the thickening where the distal tubule touches the glomerulus. They play key sensory and regulatory functions in the maintenance of body fluid, electrolyte homeostasis and blood pressure. The macula densa senses variations in the distal tubular fluid microenvironment (tubular salt, metabolites and flow) and the generation and release of paracrine mediators for tubulovascular cross talk that controls afferent arteriole vasoconstriction (tubuloglomerular feedback) and renin secretion.

1. Micturition

This is also known as **Urination/ Voiding of the bladder**. It is the process of expelling urine from the bladder. There are various stages of Micturition but before we talk about the process, there are some important things we need to know. In humans, there is the excretory system and it includes a pair of kidneys, two ureters, a urinary bladder and a urethra.

The Kidneys filter the urine and it is transported to the urinary bladder via the ureters where it is stored till its expulsion. The process of micturition is regulated by the nervous system and the muscles of the bladder and urethra. The urinary bladder can store up to 350-400ml of urine before it expels it out.

Now the stages of micturition are;

a) **Resting or Filling Stage;**

In this stage, urine is just simply entering then urinary bladder and it's being stored there. The urine is transported from the kidneys via the ureters into the bladder. The ureters are a thin muscular tube that arise from each kidney and extends downwards where they enter the bladder obliquely. The oblique nature of the opening of the bladder prevents urine from re-entering the ureters seeing that the opening of the ureters into the urinary bladder is not guarded by any sphincter or muscle. As the urine is entering into the urinary bladder, the detrusor muscle is relaxing thereby allowing the bladder to distend and accommodate more urine.

b) **Voiding Stage;**

In this stage, urine is being expelled from the urinary bladder. Both the urinary bladder and urethra come to play in this stage. Once the urinary bladder's full capacity has been reached, the detrusor muscle beings to contract and the stretch receptors in the walls of the bladder send an impulse via the pelvic nerve to the brain via the spinal cord. Within the nervous system, the process is governed by the autonomous nervous system and the somatic system. The bladder and the urethra receive the signal from the brain to empty the bladder, this signal is excitatory and they stimulate the bladder to contract, this contraction further excites the stretch receptors and starts a positive feedback loop, it also relaxes internal urethral sphincter (urine is voided unless inhibited by the brain). The descending signals from the cerebral cortex travel via corticospinal tracts to the sacral spinal cord, and inhibit the somatic motor neurons and relax the external urethral sphincter. The muscles of the abdomen play a role by putting pressure on the bladder wall. This leads to complete emptying of the bladder. If we must suppress the urge to urinate results in the stretch receptors fatiguing and stop firing. 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.

Some disorders include;

- **Urinary Incontinence;** inability to hold the urine; involuntary leakage from the bladder. Can result from incompetence of the urinary sphincters, bladder irritation, pressure on the bladder in pregnancy, an obstructed urinary outlet so that the bladder is constantly full and dribbles urine (overflow incontinence); uncontrollable urination due to brief surges of bladder pressure, as in laughing or coughing (stress incontinence); and neurological disorders such as spinal cord injuries.
- **Urethritis;** this is a condition characterized by the inflammation of the urethra. It is most commonly caused by bacteria either through sexual intercourse or from non-sexual sources. Symptoms include burning sensation on passing urine, frequent urination, and pain in the abdomen before and after passing urine.

- **Anuria;** this is a condition characterized by no passage of urine.
- **Polyuria;** excessive or frequent urination. This occurs when the kidneys are unable to filter and reabsorb water from the urine.

2. **Role of Kidney in the regulation of Blood Pressure.**

The kidneys remove waste product and excess water from the body and so help to regulate blood pressure. Evidence that the kidneys play a key role in blood pressure regulation comes from the fact that chronic abnormalities of blood pressure control, such as hypertension, almost always begin with some abnormality of renal function. Renal control of extracellular volume and renal perfusion pressure are closely involved in maintaining the arterial circulation and blood pressure. Renal artery perfusion pressure directly regulated sodium excretion; a process known as Pressure Natriuresis and influences the activity of various vasoactive systems such as the renin-angiotensin-aldosterone (RAS) system. The blood pressure in the body depends upon;

- The force by which the heart pumps out blood from the ventricles of the heart.
- The degree to which the arterioles and arteries constrict
- The volume of blood circulating round the body

The kidney influences blood pressure by;

- Causing arteries and veins to constrict
- Increasing the circulating blood volume

The macula densa sense the sodium (Na) in the filtrate, while the juxtaglomerular cells sense the blood pressure. When the blood pressure drops, the amount of filtered Na also drops. The arterial cells sense the drop in blood pressure and decrease in Na concentration is relayed to them by the macula densa cells. The juxtaglomerular cells release and enzyme called Renin. Renin converts angiotensinogen into angiotensin-1 which is then converted to angiotensin-2. Angiotensin-2 causes blood vessels to contract- the increased blood vessels constrictions elevate the blood pressure. When the volume of blood is low, arterial cells/juxtaglomerular cells in the kidneys secrete renin directly into circulation.

3. **Role of kidney in Glucose Homeostasis.**

The kidney plays an important role in glucose homeostasis by reabsorbing all the filtered glucose, an adaptive mechanism that ensures sufficient energy is available during fasting periods. The kidney is involved in glucose homeostasis via three different mechanisms;

- Release of glucose into the circulation by Gluconeogenesis
- Uptake of glucose from the circulation to satisfy its energy needs
- Reabsorption into the circulation of glucose from glomerular filtrate to conserve glucose carbon.

Gluconeogenesis is a metabolic pathway that results in the generation of glucose from certain non-carbohydrate carbon substrates.

4. **Role of kidney in calcium homeostasis.**

Calcium is an important ion in cell signaling, hormone regulation and bone health. Kidneys play a role in the regulation of blood calcium level by activating 1,25-dihydroxycholecalciferol (calcitriol) into vitamin D. Regulation of calcium homeostasis occurs in the thick ascending limb and collecting segments via actions of calcium sensing receptor and several transporters. Vitamin D is necessary for the absorption of calcium from intestine. Calcitriol is a steroid hormone synthesized in the kidney. It increases the blood calcium level by increasing the calcium absorption from the small intestine.

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