Name : Agoha Chinaza R.

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Course : Renal physiology

1. Discuss the role of kidney in glucose homeostasis

The kidney helps in maintaining glucose balance by the folllowing mechanisms

- Gluconeogensis is the process by which glucose is produced from a non-glucose substrate and this happens in the kidney because the main enzymes responsible for this process are found in the kidney ( phosphoenol pyruvate carboxykinase & glucose-6-phosphatase) pow glucose level in the body triggers gluconeogenesis which helps stabilize the glucose levels

- Filtering and reabsorbing glucose : this happens at the level of proximal tubule, under normal conditions the kidney reabsorbs as much glucose as possible which makes it glucose free about 180 grams of glucose is absorbed per day and if this amount is exceeded then glucose appears in the urine which is mediated by active sodium coupled glucose transporters or passive glucose transporters

2. Discuss the process of micturition

Micturition is the process by which the urinary bladder empties when it becomes filled and it involves 2 main steps

- the bladder filled progressively until the tension in is walls rises above a threshold

- Micturition reflex which is triggered by the built up tension this empties the bladder or at least causes a conscious desire to urinate.

Micturition reflex

Once a miturition reflex starts it is self regenerative. As the bladder fills many superimposed micturition contractions appear due to stretch reflex initiated by density stretch receptors in the bladder wall these receptors are conducted to the sacral segment of the cord through the pelvic nerves and back to the bladder through the parasympathetic never fibers of these same nerves. It is a single cycle of progressive and rapid increase of pressure, a period of sustained pressure and return of basal tone of the bladder, micturition reflex may be inhibited for some minutes before another one occurs, this happens as the bladder becomes more and more filled and the reflexes become more and more powerful , once it becomes powerful enough another reflex which passes the pudendal nerves to inhibit the external sphincter causing urination this only happens when the reflex is more potent than the brain.

Spinal centers for micturition are present in the sacral and lumbar segments , these spinal centers are regulated by higher centers which may be inhibitory or facilitatory

\* inhibitory centers present in the midbrain and cerebral cortex suppress spinal micturition centers

\* Facilitatory centers in pons facilitate micturition via spinal centers

3. Explain juxtaglomerular apparatus

The juxtaglomerular apparatus of the kidney serves as an intrarenal baroreceptor composed of four basic elements which are

- the terminal portion of the efferent arteriole

- Macula densa : this is the end portion of the thick ascending segments before it opens into distal convoluted tubules, located adjacent to afferent and efferent arterioles at the vascular pole of the glomerulus . It also secrets thromboxane A2

- The extraglomerular mesangial cells : also called lacis cells or goormaghtigh cells are found outside the glomerulus near the vascular pole they play a role in renal auto regulation of blood flow to kidney through renin angiotensin system. It secretes cytokines like interleukin 2 and tumor necrosis factor

- Juxtaglomerular cells : also called granular cells (due to the presence of secretory granules one their cytoplasm) they are smooth muscle cells found within the interstitium between the macula densa and the vascular pole i.e within the afferent arteriole . They synthesize, store and secrete the enzyme renin

Functions of juxtaglomerular apparatus

A. It’s primary function is the secretion of hormones - it secretes two hormones namely;

\* renin: it is a peptide hormone which binds to angiotensin to form renin- angiotensin system which plays an important role in blood pressure maintenance e.g

- in the blood vessels it causes vasoconstriction which increases arterial blood pressure directly , it also increases the release of noradrenaline from sympathetic fibers which indirectly increases blood flow

- In adrenal cortex it stimulates the release of aldosterone which help to elevate sodium levels thereby increasing blood pressure

- On the kidney it regulates glomerular filtration rate by constricting efferent arterioles and contracting mesanglial cells, it also increases renal reabsorption of sodium

- In the brain , It inhibits baroreceptor reflexes which indirectly increases blood pressure , it also stimulates thirst, the release of anti diuretic hormone

• prostaglandin : extraglomerular mesanglial cells of juxtaglomerular apparatus are responsible for its secretion , it is also secretes by interstitial cells of the medulla

B. It also regulates glomerular blood flow and filtration rate : it does this with the help of the macula densa cells , they trigger contraction of the afferent arteriole reducing flow of blood to the glomerulus and the glomerular filtration rate. Glomerular filtration occurs due to pressure gradient in the glomerulus, increased blood volume and increased blood pressure will increase the glomerular filtration rate while constriction of the afferent arterioles and dilation of the efferent arterioles will decrease the filtration rate

4. Discuss the role of kidney in the regulation of blood pressure

There are certain nervous and hormonal factors that influence the glomerular filtration rate and tubular reabsorption and, therefore renal excretion of salt and water which have direct effect on blood volume , extra cellular fluid and other body fluid.

\* Pressure natriuresis is the effect of blood pressure on sodium excretion while pressure diuresis is the effect of blood pressure on water excretion and blood pressure has a direct effect on both of them, increases in blood pressure leads to an increase in pressure diuresis & pressure natriuresis in order to return the blood pressure to normal the blood volume has to decrease and for the fluid level in the body you decrease then salt and water most be excreted at a higher rate. This is one of the mechanism the kidney employs to maintain blood pressure in the body

\* Renin is synthesized and stored in the juxtaglomerular cells of the kidney, a drop in arterial pressure cause those cells yoo release renin which acts enzymatically on another plasma protein to produce angiotensin I which had mild vasoconstrictor properties , this is then acted on by angiotensin converting enzyme to become Angiotensin II which is a powerful vasoconstrictor, it also decreases the excretion of salt and water by the kidneys actions of the renin-angiotensin system help to raise arterial pressure back to normal

\* Angiotensin II also causes the arsenal glands to release aldosterone which in turn increases salt and water reabsorption by the kidney tubules leading to a higher arterial pressure

\* Antidiuretic Hormone (ADH) is released by the posterior pituitary gland when the osmolarity of the body fluids increases above normal, it increases the permeability of the distal tubules and collecting ducts to water this leads to decreased urine volume and also increased arterial pressure

\* Atrial natriuretic peptide (ANP)is released by the cardiac atrial muscle fibers in response to increased stretch of the atria which is as a result of excess blood volume , this peptide acts on kidneys to increase the glomerular filtration rate and decrease sodium reabsorption by the collecting ducts . These combined actions of ANP leads to increase section of salt and water which helps to compensate for excess blood volume which also has a direct effect on blood pressure

\* Nervous system : the kidneys receive extensive sympathetic innervation, a decrease in blood pressure leads to a reflex activation of the sympathetic nervous system this in turn increases renal sympathetic nerve activity which has the following effects

- Increased tubular reabsorption of sat and water

- Stimulation of renin release and increases angiotensin II & aldosterone formation

- Construction of renal arterioles which decrease glomerular filtration rate

5. Discuss the role of kidney in calcium homeostasis

Calcium is both filtered and reabsorbed in the kidneys but not secreted, normally 99% of filtered calcium is reabsorbed by the tubules while about 1% of the filtered calcium is excreted. (25-30% is reabsorbed in the loop of henle, 4-9% in the distal & collecting tubules, 65% in the proximal tubule) increase in calcium intake leads to increased renal excretion while a decrease results in the opposite.

Most calcium reabsorption in the proximal tubule occurs through paracellular pathway only about 20% occurs through the transcellular pathway in 2 steps

- calcium diffuses from the lumen into the cell down an electrochemical gradient

- Calcium exits the cell via calcium-ATPase pump and sodium-calcium transporter

Calcium reabsorption happens in thick Ascending limb in the loop of henle through the paracellular route and transcellular pathway (this process is stimulated by the parathyroid hormone) while in the distal tubule calcium reabsorption occurs through active transport similar to that in the proximal tubule and thick ascending limb which involves calcium ATPase pump and sodium calcium counter transport mechanism .

Vitamin D , calcitonin and parathyroid hormone are the main factors that stimulate calcium reabsorption but other factors like plasma concentration of phosphate, blood pressure and extra cellular fluid volume have direct effects on calcium excretion from the body