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1. Role of kidney in glucose homeostasis

This is accomplished by the formation of urine. During this time, kidney performs a lot of activities such as:

1. Excretion of waste products: it excretes products such as urea, uric acid, creatinine, bilirubin toxins, drugs, etc.
2. Maintenance of water balance: does this by conserving water when decreased in the body and excreting water when in excess.
3. Maintenance of electrolyte balance: kidney retains sodium if osmolarity of body water decreases and vice versa.
4. Maintain acid-base balance
5. Process of micturition

Micturition or urination is the process of expelling urine from the bladder. This act is also known as voiding of the bladder. The excretory system in humans 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 (parasympathetic and sympathetic divisions of autonomic nervous system and a somatic nerve called pudendal nerve) and the muscles of the bladder and urethra. The urinary bladder can store around 350-400ml of urine before it expels it out.

**Stages of Micturition**

The urinary bladder has two distinct stages or phases:

1. Resting or filling stage
2. Voiding stage

**Resting or Filling Stage**

It is in this phase of the bladder that the urine is transported from the kidneys via the ureters into the bladder. The ureters are thin muscular tubes that arise from each of the kidneys and extend downwards where they enter the bladder obliquely.

The oblique placement of the ureters in the bladder wall serves a very important function. The opening of the ureter into the urinary bladder is not guarded by any sphincter or muscle. Therefore, this oblique nature of opening prevents the urine from re-entering the ureters. At the same time, the main muscle of the urinary bladder, the detrusor muscle, is relaxing allowing the bladder to distend and accommodate more urine.

**Voiding Stage**

During this stage, both the urinary bladder and the urethra come into play together. The detrusor muscle of the urinary bladder which was relaxing so far starts to contract once the bladder’s storage capacity is reached.

The urethra is controlled by two sets of muscles: The internal and external urethral sphincters. The internal sphincter is a smooth muscle whereas the external one is skeletal. Both these sphincters are in a contracted state during the filling stage.

As mentioned earlier, the process of micturition is governed by both the nervous and muscular systems. Within the nervous system, the process is governed by the autonomous nervous system and the somatic system. Once the urinary bladder reaches its maximum capacity, the stretch receptors in the walls of the bladder send an impulse via the pelvic nerve to the brain via the spinal cord.

The micturition reflex is ultimately generated from the level of the spinal cord after it receives reflexes from the pontine region in the brain. Once the bladder and the urethra receive the signals to empty the bladder, the two sphincters relax and the detrusor muscle causes the contractions of the bladder.

Along with these muscles, the muscles of the abdomen also play a role by putting pressure on the bladder wall. This leads to complete emptying of the bladder.

1. Explain juxtaglomerular apparatus

The juxtaglomerular apparatus is a specialized structure formed by the distal convoluted tubule and the glomerular afferent arteriole. It is located near the glomerulus of each nephron. it is formed by 3 structures:

1. Macula densa

It is the end portion of the thick ascending segment before opening into distal convoluted tubule. It plays an important role in tubuloglomerular feedback mechanism. It also secretes thromboxane A2.

1. Extraglomerular mesangial cells.

Found in triangular region bounded by afferent arterioles, efferent arterioles and macula densa. It secretes prostaglandins and cytokines.

1. Juxtaglomerular cells.

They are specialized smooth muscles cells situated in the wall of afferent arteriole just before it enters the Bowman’s capsule.

**Functions of juxtaglomerular apparatus.**

1. Secretion of hormones.

It secretes two hormones: Renin and Prostaglandin. Renin forms the renin-angiotensin systems which plays an important role in maintenance of blood pressure.

1. Secretion of other substances
2. Regulation of glomerular blood flow and glomerular filtration rate.
3. Role of kidney in the regulation of blood pressure.

kidney plays a role in the long term regulation of arterial blood pressure. It does this by two ways:

1. By regulation of extracellular fluid volume (ECF)

When blood pressure increases, kidney extract large amounts of water and salt, especially sodium by pressure diuresis and pressure natriuresis. Pressure diuresis is the extraction of large quantity of water in urine due to increased blood pressure. Pressure natriuresis is the extraction of large quantity of sodium in urine. Due to these 2, the ECF volume and blood volume is decreased and blood pressure is brought back to normal.

This happens vice versa in the case of decreased blood pressure.

1. Through renin-angiotensin mechanism.

When blood pressure and ECF volume is decreased, renin secretion from kidneys is increased. It converts angiotensinogen into angiotensin I. This is converted to angiotensin II by angiotensin-converting enzyme (ACE). Angiotensin II then:

* Causes a constriction of arterioles in the body so that the peripheral resistance in increased and blood pressure rises. It also causes constriction of afferent arterioles in the kidney so that glomerular filtration reduces resulting in retention of water and salt, increase in ECF volume to normal and also blood pressure to normal.
* It also stimulate adrenal cortex to secrete aldosterone. This hormone increases reabsorption of sodium from renal tubules. Sodium reabsorption is followed by water reabsorption resulting in increased ECF volume, blood volume and blood pressure to normal.

1. Role of kidney on calcium homeostasis.

The maintenance of calcium homeostasis is very important because calcium is the main component of bony skeleton and serves as the intracellular and extracellular messenger in numerous essential cellular events such as neuronal network, immune response, muscle contraction, and hormone secretion. Total body calcium in the adult human is about **1-2 kg** and 99% of total calcium exists in bone. Even though only less than 1% of body calcium is in the extracellular space, maintaining the extracellular calcium concentration within a narrow range **(8.5-10.5 mg/dL**) is very important for calcium homeostasis. Approximately 40% of plasma calcium is protein-bound and 10% of calcium is in a complex with anions like phosphate, citrate, and sulfate etc. Only half of plasma calcium is in its free form (ionized form, iCa2+) and physiologically important. The ionized calcium is tightly regulated by hormones like parathyroid hormone (PTH), 1,25-dihydroxycholecalciferol (1,25(OH)2D3), calcitonin, and calcium itself. The kidney, intestine, and bone are the main target organs of these regulators, and the kidney plays a key role in the fine regulation of calcium excretion.

About 50% of plasma calcium (ionized and complexed form, excluding the protein bound form) is freely filtered through the renal glomerulus, and 99% of the filtered calcium is actually reabsorbed along renal tubules. The excreted calcium in the final urine is about 200 mg per day in an adult person with an average diet. Several factors are involved in the regulation of calcium in renal tubules. PTH and activated vitamin D enhance calcium reabsorption in the thick ascending limb (TAL), distal convoluted tubule (DCT) and/or connecting tubule (CNT), and oestrogen promotes calcium absorption in the DCT/CNT. Acidosis contributes to hypercalciuria by reducing calcium reabsorption in the proximal tubule (PT) and DCT, and alkalosis vice versa. Diuretics like thiazide and furosemide also alter calcium absorption in the renal tubules; thiazide promotes calcium reabsorption and furosemide inhibits it. Plasma calcium itself also controls renal calcium absorption through altered PTH secretion as well as via binding to the calcium sensing receptor (CaSR) in the TAL. To facilitate Ca2+ reabsorption along renal tubules:

(i) voltage difference between the lumen and blood compartment should be favorable for Ca2+ passage, i.e., a positive voltage in the lumen

(ii) concentration difference should be favorable for Ca2+ passage with a higher Ca2+ concentration in the lumen

(iii) an active transporter should exist if the voltage or concentration difference is not favorable for Ca2+ reabsorption. Each renal tubular segment has a different Ca2+ concentration difference or voltage environment for its unique mechanism for calcium reabsorption.