PONTIFICIA UNIVERSIDAD CATÓLICA DE VALPARAÍSO

SPECTO PUCV
Desarrollo de Competencias Metavisuales

Renal Physiology

SPECTO

DEVELPMENT OF METAVISUAL COMPETENCIES

Renal Physiology: From blood filtration to tubular reabsorption.

Director

Dr. Cristian Merino Rubilar
Laboratory of Chemistry Education
Instituto de Química

Content Team

- Alexis A. Gonzalez, PhD in Physiology
- Cristian Merino, PhD in Science Education
  Instituto de Química

Technologic and Graphic team

- Sonia Pino Espinoza.
  Project Engineering
- Humberto Vergara.
  App developer
- Roberto Morales Zúñiga
  3D Designer
- Eduardo Becerra Gamboa.
  Interface designer
- Center *Costadigital PUCV*.

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From filtration to tubular reabsorption

Introduction

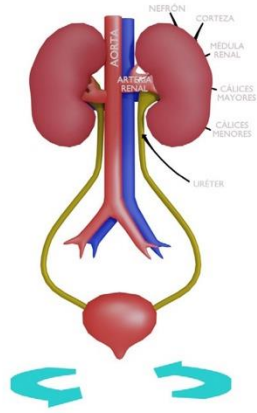
The kidneys are essential organs for maintaining body fluids, directly impacting the water and electrolyte composition of the blood and the interior of our cells. The kidneys also have a filtration and waste elimination function, without which we will not be able to survive. Thanks to the kidney's ability to reabsorb and recycle water and sodium, we can keep body volumes in balance, which ultimately impact blood pressure. Other less known functions of the kidney are the production of hormones that promote the formation of red blood cells (erythropoietin) and the synthesis of vitamin D, essential for calcium deposition in our bones. Now we can imagine how important it is to take care of our kidneys!!!

Activity 1. ¿How is the structure of the filter system in the kidneys?

Objective:

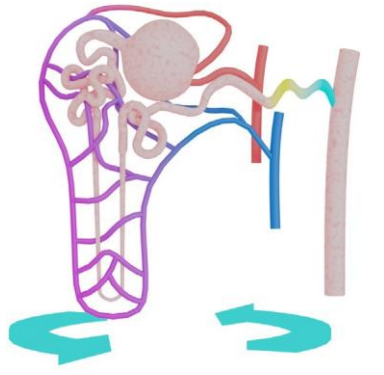
To analyze and identify the main macroscopic and microscopic anatomic structures of the kidney

1. Look and analyze the sequence of images that contextualize the kidney structures at macroscopic level. Observe the anatomical position of both kidneys in the human shape, identify the aorta artery from where the left and right renal artery originates. Did you know that both kidneys consume 25% of the blood ejected by the heart? In this sequence of images, you can see the macroscopic structures that are distinguished from the kidney, such as the renal cortex and medulla, the calyces and the ureter.



SCAN 1

2. Observe and analyze in detail the sequence of images that show the microscopic aspects of the kidney anatomy. In this sequence, use the zoom towards the internal structures of the kidney that will finally take you to the functional unit of the kidney called the nephron where the blood comes from the afferent arteriole to the glomerulus and the blood filtration occurs. Using the action buttons, you can identify the afferent arteriole, efferent arteriole, Bowman's capsule (external structure), and the glomerular capillaries surrounded by cells called podocytes. Once the blood is filtered to the Bowman's space, the urine is formed and then directed towards the most distal tubules of the nephron, the first segment of which is called the proximal tubule.



SCAN 2

Activity: Describe -step by step- the journey of the blood from the aorta towards the renal arteries to return from the kidneys to the vena cava, including each segment of the renal structure.

Activity 2. What things are filtered and what are not? What things should we reabsorb?

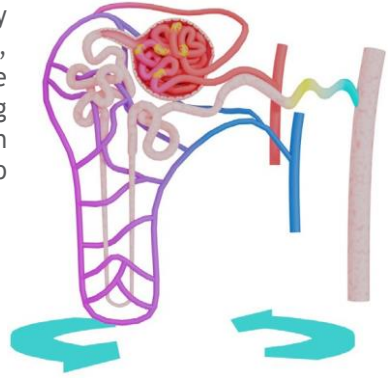
Objetives:

To understand what we call the filtration barrier in the glomerulus.

To understand that as terrestrial animals, we must recycle the greatest percentage of water and sodium as we can, which are fundamental for the homeostasis of the water-salt balance in our body.

For the process of blood filtration and waste elimination to occur, the blood must pass through a ball of capillaries which have small holes (fenestrations) that allow the passage of very small molecules, but not large molecules. Additionally, these capillaries are surrounded by cells called podocytes which surround the capillaries, forming a kind of second layer in a kind of strainer. The pedicels of each podocyte contain abundant negatively charged proteoglycan molecules, which prevents, for example, proteins (generally negatively charged in the blood) from being able to cross this barrier.

Once the filtration process has occurred, a part of the liquid has left through the capillary fenestrations towards Bowman's space, also carrying with it unnecessary substances, toxins and waste substances which will travel along the renal tubules. However, some substances must be reused and reabsorbed. Water and sodium are important in regulating body fluids. The lack of water makes it necessary for us to reuse and reabsorb as much water as possible. Therefore, our kidneys must reabsorb these elements according to their needs.



Now let's analyze. What molecules do you think are easily filtered? Observe the following sequence, look at the molecules they pass through and look for their approximate molecular size.

SCAN 3

Answer the following questions:

1. Explain what is the function of negatively charged proteoglycans in those that are part of podocytes?
2. How can you relate molecule size versus filtration capacity? Could you ensure that a molecule like glucose is filtered? Can you confirm that a protein-like hemoglobin can be filtered? Try to compare their sizes.
3. In pathological conditions the glomerulus can suddenly become inflamed, allowing large molecules to pass through to cells, for example, in a condition of bacterial infection in the blood, which could affect the capillaries, causing them to become inflamed. What substances or molecules would you expect to detect or see in the urine of a patient with severe inflammation of their glomeruli? Explain what you think would happen.
4. What substances are essential for our body and therefore are continually reabsorbed throughout the renal tubule?
5. In which area is the most water and sodium reabsorbed?
6. What happens if you don't drink water for a whole day, what will your urine be like at the end of the day? Concentrated or diluted? In which area of the nephron do you think the greatest water absorption occurred while you were without drinking water?

The case of the Urea

Did you know that urea is a waste product, but it is also useful for us to concentrate our urine, allowing us to reabsorb water?

Urea is eliminated from the blood; it is filtered by the glomerulus and is not reabsorbed because it is not useful for our body. Interestingly, urea functions as a recycling system in the renal medulla between the collecting duct and the ascending loop of Henle where it is reabsorbed from the urine in the collecting duct to the renal medulla where it accumulates transiently and then re-enters to the loop of Henle, theoretically, same molecule is reabsorbed back into the renal medulla, producing a cyclic system of recycling allowing high concentration of urea in the medulla. This hyperosmotic interstitum is the driving force for water reabsorption in the collecting duct.

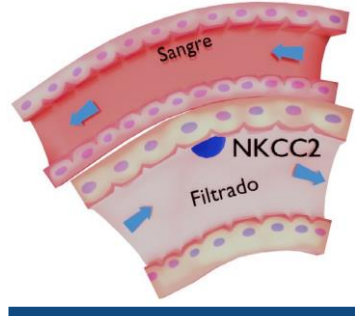
In the application, activate the “UREA” button to visualize what happens with urea, a waste molecule, which, although it is eliminated from the blood, recirculates in the renal medulla between the loop of Henle and the collecting duct, increasing the osmolarity of in the interstitial medulla favoring water transport and reabsorption from the collecting duct, in which urine is forming.

Activity 3. The Kidney is also responsible for the maintenance of arterial blood pressure

Objetive:

To know how the kidney can maintain arterial blood pressure by understanding the tubulo-glomerular feedback mechanism

Our kidneys are key organs in responding to and detecting a sudden drop in blood pressure, for example due to a hemorrhage or due to a decrease in blood volume due to loss of water from the blood to the tissues (edema). Through a mechanism it does not require nervous control and can occur even in an experimentally isolated kidney. This mechanism depends on the connection between the filtrate and the glomerulus.



SCAN 4

Once the blood is filtered, the filtrate passes through the proximal tubule, the thin and thick loop of Henle and reach the glomeruli again. However, the filtrate is not mixed with the blood, there is only a close contact with a special type of cells in a specific structure called the *macula densa* (tubular cells in contact with the afferent arteriole) which is able to sense changes in sodium in the filtrate. In this way, an extreme decrease in the concentrations of sodium, chlorine and potassium in the *macula densa* is indicative of a decrease in filtration and therefore our blood volume. In this case the cells of *macula densa* will send molecular signals so that the afferent arteriole to promote the secretion of the hormone "renin", which will activate the synthesis of Angiotensin II, a powerfull peptide that is able to constrict our arteries, thus ensuring increased pressure to supply blood to important organs such as the brain.

Based on the structure and the previous video, hypothesize in each case what would happen.

1. What happens with glomerular filtration if you have a hemorrhage causing that blood pressure decreases?
2. What Happens with the amount of sodium that is filtered and passes through the *macula densa*?

Activity 4. Final conclusions

Now that you know the functions of the kidney, could you draw a final diagram that integrates the mechanisms that you have already learned in this learning sequence?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