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ASSIGNMENT

Urinary System Histology

1. Critically examine the renal function of desert dwellers and the anatomical adaptation.
2. Write extensively on the clinical importance of the Glomerular filtration barrier

1. Critically examine the renal function of desert dwellers and the anatomical adaptation.

The desert animal rarely drinks water. The kidneys ability to excrete wastes while conserving water is important. Especially, during periods where the body is losing water, or when intake is low. The nephrons and blood vessels of the mammalian kidney are assembled into elaborate tubular networks. The nephrons and vessels interact with each other, exchanging water and solutes among many spatially distinct compartments in a highly orchestrated manner in order to produce urine that is concentrated in solutes. The kangaroo rat is a desert species, which remarkably drinks no free water and can produce urine that is twice as concentrated as that of the common laboratory rat and about five times that of humans.

Much of the concentrating effect occurs in a region of the kidney known as the medulla. The medulla is separated into two zones; the inner medulla and the outer medulla. The ability of mammals to produce concentrated urine requires that the solute concentration of the inner medulla substantially exceeds that of the outer medulla. This concentration difference between the two zones is known as the medullary solute gradient. Water channel aquaporin 1 is expressed at significantly higher levels in some nephrons of the kangaroo rat.

Spiny mouse, which is a desert dweller, has a significantly lower Glomerular number, increased Glomerular size and a more densely packed renal papillae compared with the similar sized laboratory adapted mouse. Basal food and water intake, urine and feces production, and urinary electrolyte concentration were not different between species, although urinary urea concentrations were higher in spiny mice.

On normal salt spiny mice was approximately 18mmHg lower, effective renal plasma flow was 40% lower, and Glomerular filtration rate tended to be lower than in C57BL/6 mouse. Filteration fraction was greater in both species on the high salt diet. Spiny mice had greater GFR and ERPF after the high salt diet, wheras the C57BL/6 mouse showed little change in GFR.

The meerkats are adapted to living in the harsh desert environment. Dark patches around their eyes help them be effective lookout by reducing the glare of the sun. Their eyes also allow them to take in a wide angle view of the scene. This helps prevent predators from gaining an advantage by sneaking up. Meerkats have light brown fur with a gray and brown tint to it with stripes on their back. Their dark-skinned bellies are covered with only a thin layer of fur, allowing the meerkats warm themselves by lying face up in the sun. Meerkats are omnivores. The meerkat has a specialized thermoregulation system that helps it survive in its harsh desert habitat. A study showed that its body temperature follows a diurnal rhythm, averaging 38.3 °C (100.9 °F) during the day and 36.3 °C (97.3 °F) at night. As the body temperature falls below the thermoneutral zone, determined to be 30–32.5 °C (86.0–90.5 °F), the heart rate and oxygen consumption plummet; perspiration increases sharply at temperatures above this range. It has a basal metabolic rate remarkably lower than other carnivores, which helps in conserving water, surviving on lower amounts of food and decreasing heat output from metabolic processes. During winter, it balances heat loss by increasing the metabolic heat generation and other methods such as sunbathing. Some physical adaptations are; Sharp, long, curved claws that dig tunnels in the ground, Sharp teeth to eat prey, color of fur to camouflage with desert surroundings. Dark circles around eyes to prevent glare in their vision. The camel does have a special kidney and a special GI tract. The camel's kidney actually can concentrate the urine more than sea water

but less than a dessert rat. Since the camel can concentrate the urine more than sea water, salty water intake won't harm the animal. The major function of the enzyme alkaline phosphatase is transporting across cell membranes. The presence of this enzyme has not been investigated in the kidney of the camel.

The camel has wide feet for walking in sand. They have long eyelashes and thin to protect the eyes from the sun and san, slit nostrils that they can close to protect them from blowing sand. They are adapted to survive a long time without water and food. They have an extremely long large intestine that absorbs every last drop of water from the foods they eat. On a long trip, the fat in their humps will break down to supply their body with the energy it needs. By the end of a difficult trip, their humps may lay over on their side, emptied of the fat that filled them. When the camel finally reaches water, it can drink a huge amount very quickly to replenish itself, but it will take a little while to eat enough to rebuild its humps. The lips are thick to help the camel eat the prickly shrubs. There is a thick coat of hair even inside the camel’s ear. Camel body temperature keeps fluctuating from 34°C to 41.7°C (93°F-107°F.). This helps the animal sweat less.

2.

Clinical importance of the Glomerular filtration barrier

Nephrotic Syndrome

The nephrotic syndrome is a set of symptoms that include the following; protein in the urine, low blood protein levels, swelling or edema.

It may also include elevated levels of serum lipids, anemia, and vitamin D deficiency, all because of loss of plasma proteins into the urine. This can have

multiple causes, but all involve defects in the glomerular barrier to proteins so that excess proteins are filtered and thereby excreted in the final urine.

There are three barriers which are the; the fenestrated endothelial cell layer, the GBM, and the podocyte and slit diaphragm.

Nephrotic syndrome can be primary or secondary. Primary causes are described by their histological changes; minimal change disease, focal segmented glomerulosclerosis, and membranous nephropathy. Secondary causes are described by their underlying cause, which include diabetes mellitus, sarcoidosis, hepatitis C, bacterial infections, parasitic infections and more.

All of the diseases are characterized by protein in the urine, at least 3.5 g per 24 h. The loss of protein can cause hypoalbuminemia, with resulting edema that may show as puffiness around the eyes, pitting edema in the legs, and pleural effusion. Loss of proteins stimulates liver synthesis, including lipoproteins. Because lipoprotein lipase levels fall, lipoprotein levels increase. Loss of vitamin D binding protein can lead to vitamin D deficiency diseases, with calcium malabsorption and bone disease.

Mutations of nephrin, a protein of the filtration slit, cause nephrotic syndrome. Mutations of podocin also cause nephrotic syndrome that is insensitive to steroid treatment. Podocin is an integral protein of the podocyte cell membrane that segregates into lipid rafts and is required to recruit nephrin into those rafts. Current thought is that podocin and nephrin form a signaling complex that activates protein kinases involved in glomerular structural integrity. These mutations cause minimal change diseases in which structural changes are evident only at the electron microscope level and not at the histological level. Until recently, these were part of the set of nephrotic syndrome called idiopathic nephrotic syndrome.

Membranous glomerulonephritis is one of the more common causes of nephrotic syndrome in adults. It is an inflammatory disease, believed to be caused by binding of antibodies to antigens in the GBM that triggers the formation of a membrane attack complex from complement.

This triggers release of proteases and oxidants that damage the capillary walls, causing them to become leaky. Histology reveals thickened basement membranes.

Treatment depends on etiology. For all nephrotic syndromes, monitoring and maintaining normal fluid levels and distribution among the body compartments are the goal. This could include restriction of fluid intake, restriction of salt intake, regular monitoring of blood pressure and urine output, and the use of diuretics. Inflammatory causes of nephrotic syndrome are treated with immunosuppressant such as prednisolone and dietary modification.