Kidney function

It is said that we are what we eat. Because thefoodwe eat is assimilated into our blood. And the nutrients circulating in our bloodstream replenish every cell of our body. On the other side of the coin, this blood needs to be constantly cleaned and maintained at an equilibrium. This is where the kidneys come in. It is the function of the kidneys to continually filter out the impurities and toxins from the blood. After the body tissues have taken what is needed from the nutrient-laden blood, waste is sent back to the blood. If our kidneys did not remove these waste substances, they would build up in the blood to the point of death. Kidneys excrete the unwanted stuff from the blood and retain only the essential ingredients. In this sense, it can be said that we are indeed what our kidneys keep. Kidneys are such vital organs of the body that we can only keep going as long as the kidneys keep functioning.

The kidneys regulate the composition of the blood by 1) removing waste chemicals from metabolism of body’s tissue cells and various chemicals that have been detoxified by the liver (such as drugs, toxins and hemoglobin breakdown products) – i. e. excretion 2) maintaining the concentrations of various ions (including sodium, potassium, chloride, calcium, magnesium, sulfate, phosphate) and other important substances at optimum levels - i. e., osmoregulation. 3) keeping the volume of water and in the body at the right levels and 4) keeping the acid/base concentration of the blood constant.

Besides regulating the blood composition, kidneys also help maintain the body’s blood pressure through the action of an enzyme called renin. Further, they actually help new blood cells to generate from the bone marrow. This they do by acting in the capacity of endocrine glands by releasing a hormone called erythropoietin. The kidneys also release a hormone called calcitrol which helps the body sythesize calcium.

Blood is pumped down from the heart, and the kidneys receive this blood through a branch of aorta called the renal artery. Although the kidneys are relatively small in size and constitute less than 1% of the total body weight, they can take in up to 20% of the body's total blood volume at a time. Blood flows from the renal artery into progressively smaller arteries, the smallest being the arterioles. From the arterioles, blood flows into tufts of microscopic capillaries called glomeruli. Blood exits each glomerulus through another arteriole, which connects to a small vein. The small veins join to form a single large renal vein, which carries blood away from each kidney. After the processing of the blood, the purified blood is returned to the body through the renal vein and the filtered-out waste products and other unwanted substances move out through the ureter. Urine flows from the kidneys through the ureters to the bladder.

The kidneys filter and return to the bloodstream about 200 quarts of fluid every day. of which about two quarts are removed from the body in the form of urine.

Excretion in the kidneys removes water, inorganic ions, products of detoxification of blood, and nitrogenous waste products that result from the metabolism of protein taken into the body in food. Protein is broken down by the process of digestion into amino acids which are carried to the liver by the blood and get converted into body protein. But the surplus amino acids which cannot be stored by the body undergo a process of deamination, i. e. are broken down. Ammonia is formed as a by-product. Ammonia is an extremely toxi substance. Inside the liver it combines with carbon dioxide in a series of reactions known as the ornithine cycle. Urea is formed as a result, which then passes into the circulation and is carried to the kidney, is processed by nephrons and then excreted in the urine. With waste products thus expelled from the body, the purity of the blood is restored – an this is a continuous process inside our bodies.

The Nephron

The key functional unit of the kidney is called the nephron. Each kidney contains about a million nephrons. It is these nephrons that contain glomureli. Each nephron consists of a glomerulus surrounded by a thin-walled, bowl-shaped structure (Bowman's capsule), a tiny tube (tubule) that drains fluid from a space in Bowman's capsule, and a collecting duct that drains the freshly-formed urine from the tubule. Each of these tubules has three parts: the proximal convoluted tubule, the loop of Henle, and the distal convoluted tubule. It is in this closely packed intricate network of glomeruli and tubules that the basic process of blood filtering takes place.

Nephrons regulate water and electrolytes in the body by filtering the blood, after which necessary fluid and molecules are reabsorbed and unneedes substances are secreted. Reabsorption and secretion are accomplished with both cotransport and countertransport mechanisms established in the nephrons and associated collecting ducts.

Blood enters the glomeruli at high pressure. Much of the fluid part of blood is filtered through small pores in the glomeruli, leaving behind blood cells and most large molecules, such as proteins. Thus filtered fluid then enters Bowman's space and passes into the tubule leading from Bowman's capsule.

In the first part of the tubule, most of the sodium, water, glucose, and other substances are reabsorbed and returned to the blood. In the next part of the tubule, the remaining sodium, and potassium, and chloride are pumped out, and the resulting fluid becomes increasingly dilute. The dilute fluid then passes through the next part of the tubule, where more sodium is pumped out in exchange for potassium and acid, which are pumped in. A complex series of chemical exchanges constantly take place inside the glomeruli and tubules of nephrons.

The Kidneys and the Liver

There is also another major organ responsible for filtering out toxins from the blood, and that is the liver. The liver performs several roles in carbohydrate and lipid metabolism. Further, the liver breaks down toxin substances, and it also breaks down hemoglobin. Food nutrients entering the liver from the intestine are changed into forms usable by the body cells or are stored for future use. Fats are converted into fatty acids and then into carbohydrates or ketone bodies and transported by the blood to the tissues. Sugars are converted into glycogen, which remains stored in the liver until it is needed for energy production, when it is reconverted into glucose and released into the bloodstream. In its role as a blood purifier, the liver metabolizes nitrogenous waste products from body processes and detoxifies poisonous substances, preparing them for elimination in the urine or feces.

The human liver secretes about one litre of bile each day to aid the digestion of fats in the food. Bile is also the medium of excretion for certain metabolic waste products, drug compounds, and toxins. Bile secreted into the common bile duct enters the gallbladder, where it is concentrated and stored. When needed, this bile flows out of the gallbladder and into the intestine. Worn-out red blood cells are destroyed in the liver, spleen, and bone marrow. A pigment, bilirubin, formed in the process of hemoglobin breakdown, is released into the bile, creating its characteristic greenish-orange colour.

The red blood cells are degraded at end of their lives in liver and spleen, with hemoglobin breaking down to heme and globin. Erythrocytes of red blood cells carry oxygen and carbon dioxide by binding them with iron in hemoglobin. Erythrocyte production in the body is stimulated by a hormone called erythropoietin, secreted mainly by kidneys. The fixed phagocytic cells of the spleen and bone marrow destroy old blood cells and convert the heme groups of hemoglobin into the pigment bilirubin. The bilirubin is secreted into the blood and carried to the liver where it is conjugated with glucuronic acid, a derivative of glucose. Some of the conjugated bilirubin is secreted into the blood, and the rest is excreted in the bile as bile pigment that passes into the small intestine. This " conjugated" bilirubin is called direct bilirubin, while the “ unconjugated” bilirubin is called indirect bilirubin.

The conjugated bilirubin that is excreted into the bile by the liver is stored in the gall bladder or transferred directly to the small intestines. Urobilinogens are colorless compounds formed by bacteria in the intestine from bilirubin after the conjugated glucuronic acid has been removed. The urobilinogen remaining in the intestine is oxidized to brown stercobilin which gives the feces their characteristic color. A small portion of the urobilinogen is reabsorbed, extracted from the circulation by the hepatocytes and excreted by the kidney. This constitutes the normal " intrahepatic urobilinogen cycle".

If a liver disease such as hepatitis interferes with the normal intrahepatic urobilinogen cycle, increased amounts of urobilinogen may appear in the urine where it is converted to yellow urobilin.

Whearas in a typical case of biliary obstruction, decreased amounts of direct bilirubin reach the intestine for conversion to urobilinogen. With little urobilinogen available for reabsorption and excretion, the amount of urobilinogen in the urine is low, which would be detected in a urinalysis.

Urinalysis

Urinalysis is a physical and/or chemical examination of the urine. It consists of a series of chemical and microscopic tests to identify urinary tract infections, kidney disease, liver disease, and diseases of other organs that may result in the appearance of abnormal metabolites (break-down products) in the urine.

In urinalysis, a small, randomly collected urine sample is examined physically for things like color, appearance, and concentration (specific gravity); chemically for substances such as proteins, glucose, and acidity vs. alkalinity (pH value). Further on, tests can be conducted for the presence of cellular elements (red blood cells, white blood cells, and epithelial cells) mircroscopic organisms, crystals, and casts (structures formed by the deposit of protein, cells, and other substances in the kidneys' tubules).

Normal Values and Deviations

Normal urine may vary in color from nearly transparent colorlessness to dark yellow. If the urine is of an unusual color that cannot be accounted for by food intake or medication, it is an indication of some abnormality. The urine specific gravity ranges between 1. 006 and 1. 030. The specific gravity varies depending on various factors such as food and the time of the day. If the specific gravity is above or below the normal range, or if it does not vary, it may indicate a kidney problem.

The urine pH value is also influenced by a number of factors. Generally the normal pH range is from 4. 6 to 8. 0. If the pH is very acidic or alkaline, beyond what could be attributed to normal levels of variation, then there could be a problem. There is usually no detectable urine glucose, urine ketones, or urine protein. Significant amounts of glucose and ketones point to uncontrolleddiabetes. There should be no red blood cells present in urine. If blood is found in the urine, it is a sure sign of trouble, possibly of a serious nature. It may indicate a urinary tract disease, or the dreaded cancer.

Bilirubin is normally not found in the urine, as it would only be present in such tiny quanties as is undetectable by a routine test. There may be a trace of urobilinogen in the urine, but bilirubin in discernable amounts in the urine is a sign of a liver or bile duct disease. Nitrites and white blood cells (leukocytes) too should not be normally present in the urine. And if they are, a strong possibility of an urinary tract infection rises.

Creatinine Clearance Test for GFR

Creatinine is a metabolite of the compound creatine that is found in muscles. Creatine is a by-product of muscle energy metabolism. It is filtered from the blood by the kidneys and excreted into the urine, in the same general manner as urea. Creatinine clearance is the process of removal of creatinine from the body, and technically signifies the volume of blood plasma that is cleared of creatinine per unit time (typically, milliliters per minute).

Creatinine clearance is used for estimating the glomerular filtration rate (GFR) of the kidneys, which is the volume of fluid filtered from the renal glomerular capillaries into Bowman's capsule per unit time. GFR measurement is often considered to be the best avilable determinant of renal function. The normal range of GFR for males is 97 to 137 ml/min, and for females is 88 to 128 ml/min. The average for men is 120 ml/min and for women 95 ml/min. The GFR may reach 200 ml/min during pregnancy.

A clearance of less than 80 ml/min is significant except in people over 80 years. A decreased creatinine clearance rate is an indication of increased blood creatinine level, and happens due to the diminished capability of kidneys to carry out their function, under conditions of abnormality and disease. A creatinine clearance of 50 ml/min or less indicates serious renal insufficiency.

The GFR can predict the signs and symptoms of uraemia, especially when it falls to below 10-15 ml/min. It must be noted that the GFR varies according to renal mass and correspondingly to body mass. In a lab report, GFR is corrected for body surface area (which equates with renal mass), which in normal humans is approximately 1. 73m2 and represents an average value for normal young men and women. Impaired renal function is indicated by a GFR of 30-80 ml/min/1. 73m2 and in cases of less than 30 ml/min/1. 73m2 – there is a strong possibility of renalfailure.

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