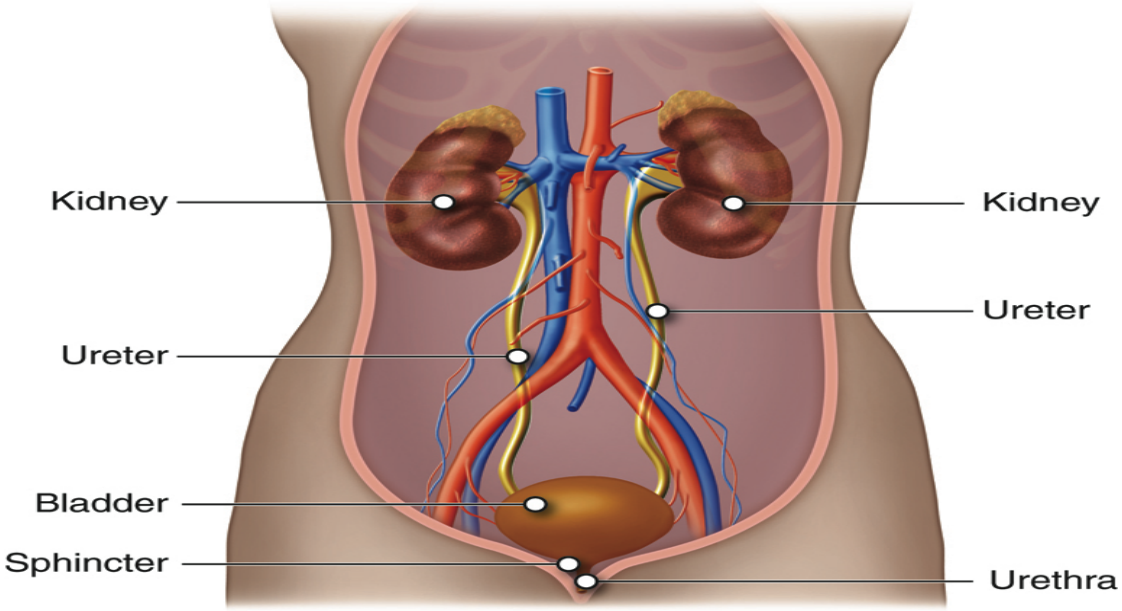
The Kidney

There are six organs in the urinary system: two kidneys, two ureters, the urinary bladder, and the urethra. The ***kidneys*** are the body's main purification system. They remove wastes, some of which are toxic, from the blood. The kidneys also help to regulate blood composition and volume. By manipulating blood volume, the kidneys contribute to the regulation of blood pressure. The kidneys are about the size of your fist and are shaped like beans. The ***nephron***, which we have already covered, is the structural and functional unit of the kidney. The average number of nephrons in each kidney is about one million, although this number can vary from about half a million to two million. Nephrons are so good at what they do that it only takes about one fourth of them to be functional to meet the needs of the body. Still, a low number of functioning nephrons have been linked to a greater risk of developing kidney disease and high blood pressure (hypertension).

Kidney Location

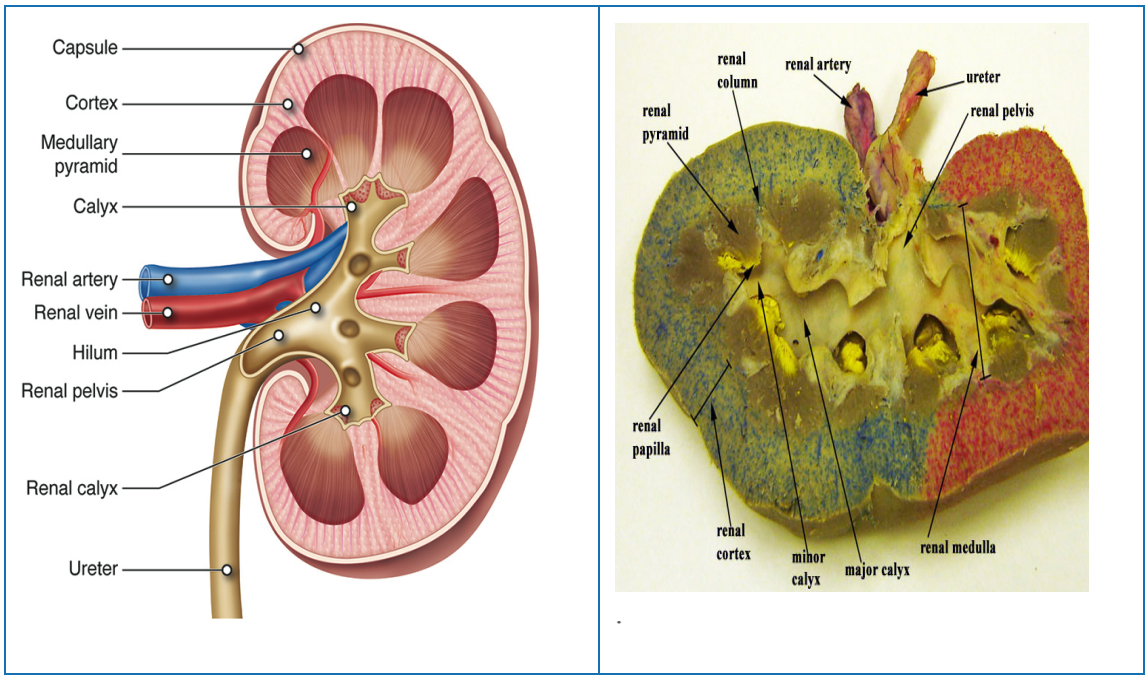
The kidneys lie between the parietal peritoneum and the posterior abdominal wall, just above waist level. The location posterior to the parietal peritoneum means they are ***retroperitoneal***. These reddish, paired organs are offered some protection by the eleventh and twelfth rib pairs. The right kidney lies slightly lower than the left kidney. This asymmetry occurs due to the increases space required by the liver on the right side of the abdominal cavity superior to the kidney.



External Anatomy

In adults, the kidney is approximately four to five inches long, two to three inches wide, and one inch thick (10 cm long, 5 cm wide and 2 cm thick). On average, each kidney weighs just less than five ounces. The kidneys have a concave medial border that faces the vertebral column. There is a depression near the middle of the concave border called the ***renal hilum***, where the renal artery enters the kidney and the renal vein, and ureters leave it.

Each kidney is enshrouded in four tissue layers. The innermost layer, the ***renal capsule***, is composed of fibrous connective tissue. It preserves the form of the kidney while protecting it from damage due to trauma. The ***adipose capsule*** or ***perinephric fat*** is the middle tissue layer. This fatty tissue mass encircles the renal capsule, offering another layer of protection from trauma and fixing the kidney in place. The ***renal fascia*** is the third tissue layer. The renal fascia is a slim layer of dense irregular connective tissue. This layer tethers each kidney to neighboring structures and to the abdominal wall. The paranephric fat forms the superficial layerand provides additional cushion and support for the kidney.



Renal Ptosis

The layers of fat surrounding them in part maintain the position of the kidneys. People who lose a lot of weight in a short period of time can also lose some of the fat that surrounds their kidneys. Very thin people may not have a sufficient

layer of fat around their kidneys. In either case, one or both kidneys may drop down into the pelvis when a person stands up, a condition called ***renal ptosis***(*ptosis*: "to fall"). For the majority of cases, people are without symptoms. However, in some cases health problems ranging from acute pain and vomiting to kinking of the ureter can occur.

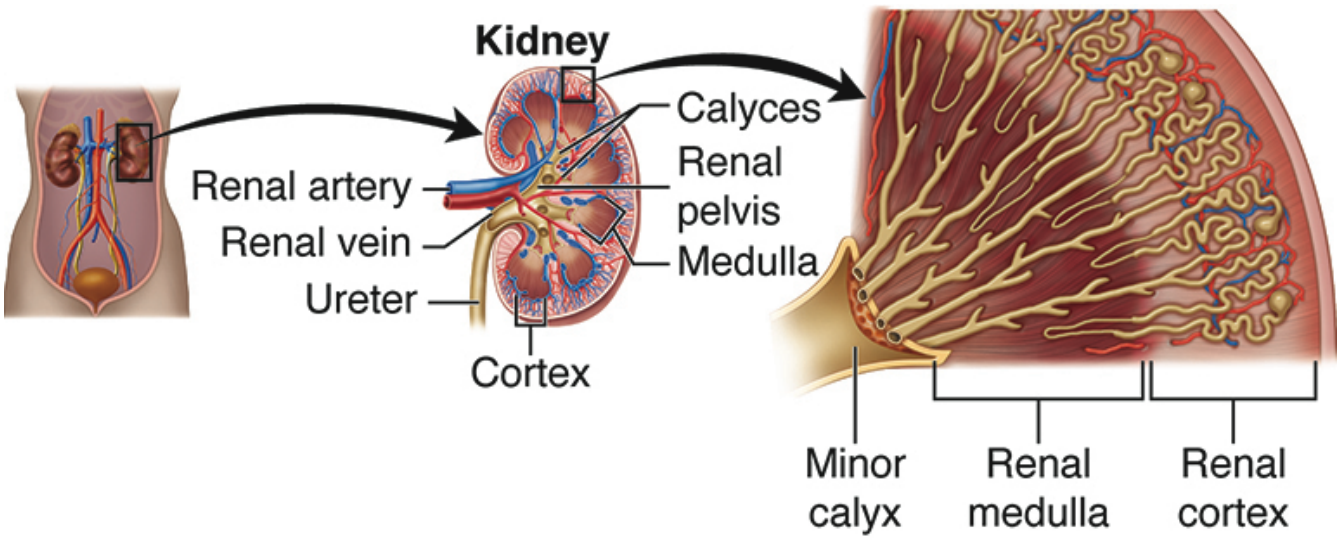
If renal ptosis creates a kink in the ureter, the kink can prevent the drainage of urine. Urine can then back up into the kidney, creating pressure that may damage renal tissue.

Diagnosis is controversial but may be confirmed by a patient experiencing relief from abdominal pain upon lying in a supine position and/or by imaging tests.

Treatment for severely symptomatic patients usually involves a laproscopic surgical procedure called ***nephropexy***. This procedure affixes the kidney to the retroperitoneal tissue, closer to its usual position.

Internal Anatomy

Two structures dominate the internal anatomy of the kidney: a deep reddish-brown area called the ***renal medulla***, and a superficial pinkish area called the ***renal cortex***. The renal medulla is made up of cone-shaped structures called ***renal pyramids*** and its primary purpose is to maintain the proper balance of salt and water in the blood. The bases of the pyramids border the renal cortex, and their apexes (***renal papillae***) face the renal hilum. The smooth-textured renal cortex runs from the renal capsule to the renal pyramid bases and extends towards the pelvis in the spaces between the pyramids. The renal cortex has an outer cortical zone and an inner juxtamedullary zone. The areas of renal cortex lying between renal pyramids are called ***renal columns***. A ***renal lobe*** consists of one renal pyramid with its surrounding renal cortex, including one half of both adjacent renal columns.



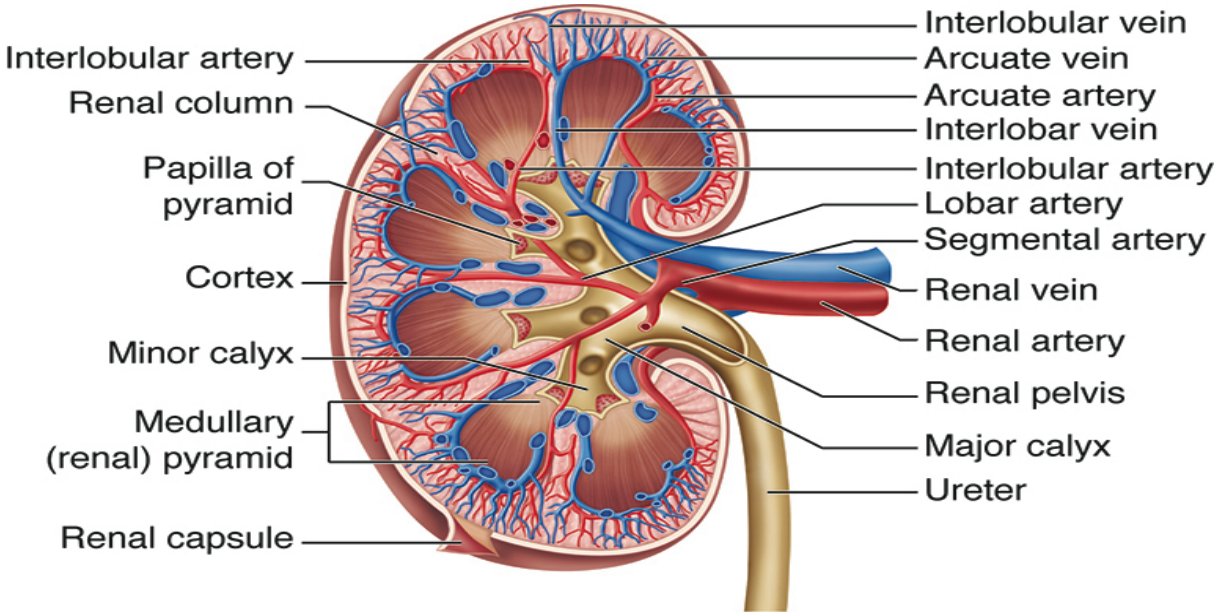
The ***parenchyma*** refers to the functional part of any organ. In the case of the kidney, the parenchyma includes the renal cortex and the renal pyramids. The actual functional units of the kidneys are microscopic structures called nephrons. Recall that there are about a million of nephrons per kidney. A low nephron number is associated with an increased risk of kidney disease and high blood pressure (hypertension).

One of the nephrons' main roles is to create urine. Urine produced by nephrons empties into large***papillary ducts***. These ducts run through the renal papillae of the pyramids. From the papillary ducts, urine flows into cup-like structures called the ***minor and major calyces*** (*calyces*: "cups"). Each kidney contains two or three major calyces and several minor calyces. The papillary ducts of one renal papilla drains into a minor calyx. As minor calyces join together, they form a major calyx. All major calyces join together to form one large chamber called the ***renal pelvis***. Urine that collects in the renal pelvis is transported out of the pelvis through the ureters and to the urinary bladder.

Within the kidney, the hilum opens up into a cavity called the ***renal sinus***, which includes a portion of the renal pelvis, the calyces, and renal blood vessel and nerve branches. These structures are held in place in the renal sinus by adipose tissue.

Blood and Nerve Supply

The kidneys' generous supply of blood vessels reflects their roles in the removal of wastes from the plasma and regulators of the volume and ionic composition of blood. Despite the kidneys accounting for less than 0.5 percent of total body mass, the right and left ***renal arteries*** transport approximately one fourth of total cardiac output (approximately1.2 quarts or 1 liter) to these organs every minute.



The large renal artery divides into several ***segmental arteries*** within the kidney that supply different areas or segments of the kidney. The segmental arteries branch into a number of ***interlobar arteries*** within the renal column. At the corticomedullary junction, the interlobar arteries branch to form the ***arcuate arteries*** (arcuate means curved). The arcuate arteries divide into smaller ***cortical radiate arteries*** (also called***interlobular arteries***) that supply the cortical tissue. The cortical radiate arteries divide into afferent arterioles, which supply nephrons. The renal cortex receives more than 90 percent of the renal blood supply.

Veins generally follow the same courses as arteries, but in reverse. From the renal cortex, blood drains first into the cortical radiate (interlobular) veins and then the arcuate, interlobar, and renal veins; there are no segmental veins. The renal veins drain into the inferior vena cava, which is located to the right of the vertebral column. Because of the position of the inferior vena cava, the left renal vein is about twice as long as the right renal vein.

Innervation of the kidneys and their ureters is supplied from an outgrowth of the celiac plexus called the***renal plexus***. This complex of autonomic nerve fibers and ganglia is primarily supplied by sympathetic vasomotor fibers. Their motor function is to adjust the diameter of renal arterioles to help regulate renal blood flow. This includes regulation of blood flow in the affrent and efferent arterioles and thus in the glomerulus. These fibers also innervate the juxtaglomerular apparatus.