

Chapter one

1.1 Introduction

Urinary stones disease remains a major health problem despite advances in diagnosis and therapy, with a lifetime incidence of up to 12% and recurrence rates of up to 50%. Renal colic can be associated with nausea and vomiting. There can be blood in the urine. There are several types of renal system stones based on the type of crystals of which they consist. The types of it are calcium oxalate, calcium phosphate, struvite, uric acid and cystine stone. The diagnosis of renal stones can be confirmed by radiological studies and ultrasound examination and urine testing diagnostic and treatment algorithms, stone burden is the most important factor to consider and forms the basis of all clinical decision making. Thus, accurate measurement of all calculi is crucial. Since its introduction, unenhanced helical computed tomography (CT) has replaced intravenous urogram and is now regarded as the reference standard in the work-up of renal colic, owing to its high sensitivity and specificity. Apart from being the diagnostic standard, CT has the advantage of providing detailed anatomical information, can identify secondary signs of stone passage, and is useful for ruling out alternate pathologies in cases of diagnostic uncertainty. Despite the advantages of unenhanced CT, ultrasound (US) is also commonly used as a diagnostic tool in the management of urolithiasis. US are recognized to be both less sensitive and specific than CT; however, it is commonly available, inexpensive to operate and poses no risk of radiation exposure. In many cases, renal and ureteric calculi are incidentally diagnosed in the workup of other conditions. It has been reported that US may detect stones as small as 0.5 mm under optimal conditions. For these reasons, some centers may still use US in the initial work-up of renal colic. (1)

Radiologic studies are necessary for making an accurate diagnosis. Classically kidney, ureter and bladder plain films (KUB), ultrasound (US) and intravenous urography (IVU) have been utilized for this purpose. Computed tomography (CT or CAT scan) is a non-invasive, diagnostic imaging procedure that uses a combination of x-rays and computer technology to produce cross-sectional images (often called slices), both horizontally and vertically, of the body. A CT scan

shows detailed images of any part of the body, including the bones, muscles, fat, and organs. CT scans are more detailed than standard x-rays. (1)

In standard x-rays, a beam of energy is aimed at the body part being studied. A plate behind the body part captures the variations of the energy beam after it passes through skin, bone, muscle, and other tissue. While much information can be obtained from a standard x-ray, a lot of detail about internal organs and other structures is not available. (1)

In computed tomography, the x-ray beam moves in a circle around the body. This allows many different views of the same organ or structure. The x-ray information is sent to a computer that interprets the x-ray data and displays it in a two-dimensional (2D) form on a monitor. (1)

CT scans may be done with or without “contrast.” Contrast refers to a substance taken by mouth or injected into an intravenous (IV) line that causes the particular organ or tissue under study to be seen more clearly, in contrast administration the patient need to be fast for a certain period of time before the procedure. (1)

CT scans of the kidneys can provide more detailed information about the kidneys than standard kidneys, ureters, and bladder (KUB) x-rays, thus providing more information related to injuries and/or diseases of the kidneys. CT scans of the kidneys are useful in the examination of one or both of the kidneys to detect conditions such as tumors or other lesions, obstructive conditions such as kidney stones, congenital anomalies, polycystic kidney disease, accumulation of fluid around the kidneys, and the location of abscesses. (2)

1.2 Problem of the study:

Knowledge of the size of the stones in pelvicalyceal system in the investigation of renal system diseases.

1.3 Objectives:

1.3.1 General objective:

Purpose of this study is to detect the size of the stones in pelvicalyceal system by using US and CT KUB reconstruction to determine types of stones by HU of urinary tract stones in both male and female.

1.3.2 Specific objective:

- 1- To evaluate the presence of stones.
- 2- To measure the size of the stones
- 3- To compare US result with CT KUB
- 4- To detect accuracy of US
- 5- To detect accuracy of CT KUB
- 6- To exclude any other pathology

1.4 Over view of study:

Chapter one included introduction, objectives, methodology of the research then concluded with the scope of the study.

Chapter two included the literature review, anatomy, physiology, pathology, computed tomography (CT) and ultrasound (US).

Chapter three included the material and method.

Chapter four included the result presentation.

Chapter five included the discussion, conclusion, and recommendation.

Chapter two

2-1 Anatomy of urinary system

2-1-1 Anatomy of the Kidneys

The kidneys are paired retroperitoneal structures that are normally located between the transverse processes of T12-L3 vertebrae, with the left kidney typically somewhat more superior in position than the right. The upper poles are normally oriented more medially and posteriorly than the lower poles. Grossly, the kidneys are bean-shaped structures and weigh about 150 g in the male and about 135 g in the female. They are typically 10-12 cm in length, 5-7 cm in width, and 2-3 cm in thickness. (3)

The indentation on the concave side of the kidney, known as the renal hilus, provides a space for the renal artery, renal vein, and ureter to enter the kidney. A thin layer of fibrous connective tissue forms the renal capsule surrounding each kidney. The renal capsule provides a stiff outer shell to maintain the shape of the soft inner tissues. (2)

Deep to the renal capsule is the soft, dense, vascular renal cortex. Seven cone-shaped renal pyramids form the renal medulla deep to the renal cortex. The renal pyramids are aligned with their bases facing outward toward the renal cortex and their apexes point inward toward the center of the kidney. Each apex connects to a minor calyx, a small hollow tube that collects urine. The minor calyces merge to form 3 larger major calyces, which further merge to form the hollow renal pelvis at the center of the kidney. The renal pelvis exits the kidney at the renal hilus, where urine drains into the ureter. (3)

The relationship of neighboring organs to the kidneys is important, as described: Superiorly; the suprarenal (adrenal) glands sit adjacent to the upper pole of each kidney; on the right side, the second part of the duodenum (descending portion) abuts the medial aspect of the kidney, on the left side, the greater curvature of the stomach can drape over the superomedial aspect of the kidney, and the tail of the pancreas may extend to overlies the renal hilum. The spleen is located anterior to

the upper pole and is connected by the splenorenal (lienorenal) ligaments inferiorly to these organs; the colon typically rests anteriorly to the kidneys on both sides, Posteriorly, the diaphragm covers the upper third of each kidney, with the 12th rib most commonly crossing the upper pole, The kidneys sit over the psoas (medially) and the quadratuslumborum muscles (laterally). (3)

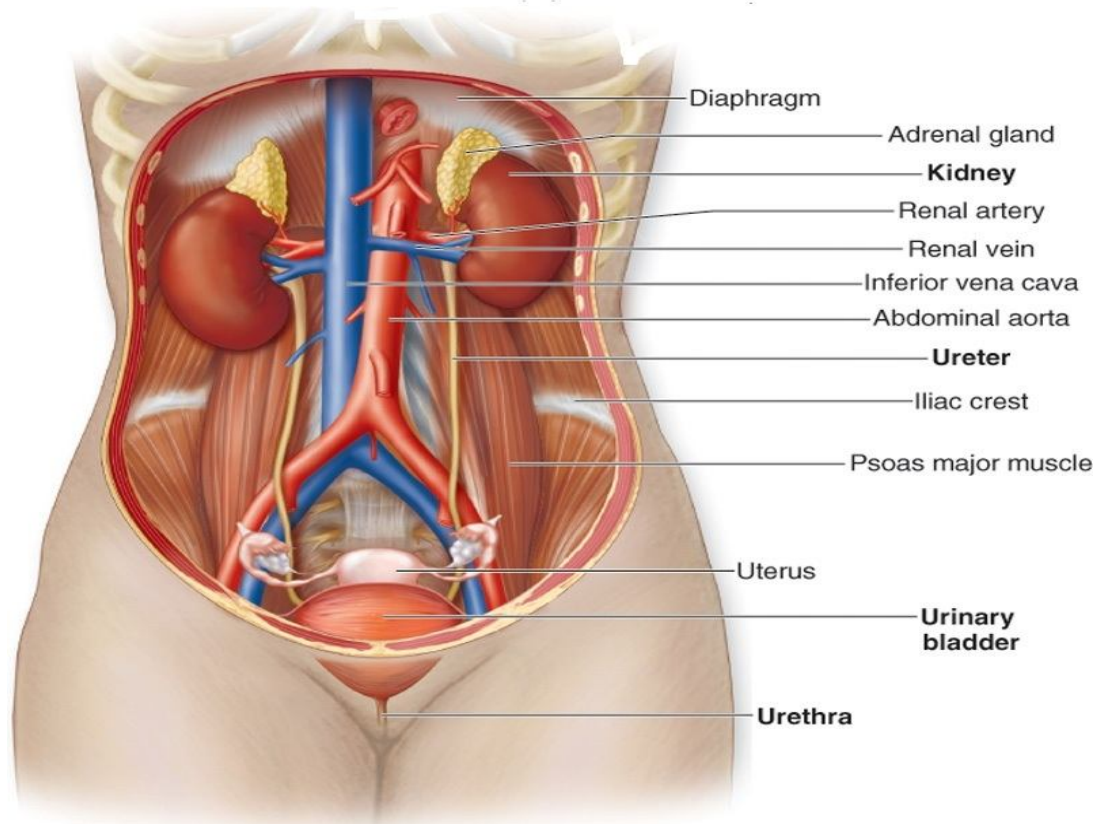


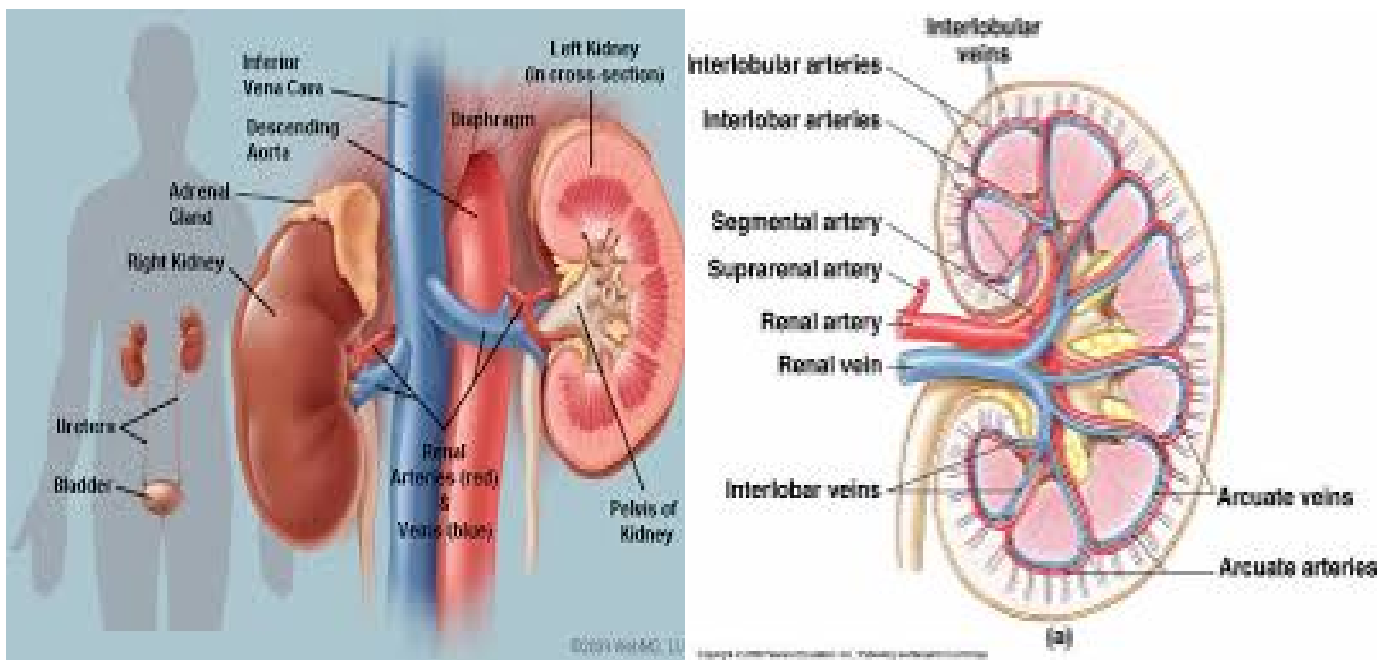
Figure 1 anatomy of urinary system (4)

2-1-1-1 Blood Supply, venous and lymphatic drainage of the kidneys

Renal Arteries arise from the aorta below the level of the superior mesenteric artery each renal artery gives off one or more inferior suprarenal arteries and branches that supply the perirenal tissue, renal capsule, pelvis and the proximal part of the ureter Accessory renal arteries are common (30% of individuals). They usually arise above or below the main renal artery and follow the hilum. Near the hilum each renal artery divides into anterior and

posterior divisions, which in turn divide into segmental arteries. (2)

These supply the 5 renal vascular segments (apical, superior (anterior), inferior, middle (anterior) and posterior). Each vascular segment is supplied by end arteries, i.e., there are no anastomoses. The initial branches of the segmental arteries are lobar, usually one to each pyramid. Before entry lobar arteries subdivide into 2 or 3 interlobar arteries. At the junction of the cortex and medulla, each interlobar artery divides into arcuate arteries. These diverge at right angles. Interlobular arteries diverge from the arcuate arteries to ascend into the cortex, to give rise to the glomerular arteries. The renal veins drain into the Inferior vena cava IVC. The left renal vein is longer than the right renal vein and receives the left suprarenal veins and left gonadal vein. On the right, these drain directly into the IVC. Lymphatic Drainage of the Kidneys is to the para-aortic lumbar nodes. (2)



a. (5)

b. (6)

Figure 2 Blood Supply and venous drainage of the kidneys

2-1-1-2 Nerve Supply of the kidney

The renal plexus is formed from the rami from the: The celiac ganglion and plexus, the aorticorenal ganglion, the lower thoracic splanchnic nerves, the 1st lumb, splanchnic nerve and the aortic plexus. The renal plexus usually continues into the kidney around the renal arteries and most renal nerves are vasomotor will Sensory nerves pass back to the CNS with the thoracic splanchnic nerves and the renal plexus gives rise to the ureteric and gonadal plexuses. (7)

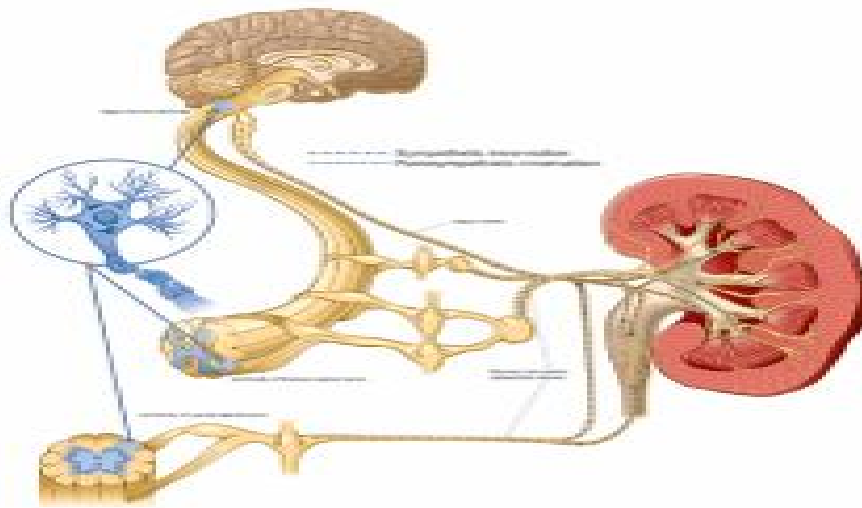


Figure 3

Nerve Supply of the kidneys (7)

2-1-2 Anatomy of the ureters

The ureters are the two tubes which convey the urine from the kidneys to the urinary bladder. Each commences within the sinus of the corresponding kidney as a number of short cup-shaped tubes, termed calyces, which encircle the renal papillæ. Since a single calyx may enclose more than one papilla the calyces are generally fewer in number than the pyramids—the former varying from seven to thirteen, the latter from eight to eighteen. The calyces join to form two or three short tubes, and these unite to form a funnel-shaped dilatation, wide above and narrow below, named the renal pelvis, which is situated partly inside

and partly outside the renal sinus. It is usually placed on a level with the spinous process of the first lumbar vertebra. . (7)

The Ureter Proper measures from 25 to 30 cm. in length, and is a thick-walled narrow cylindrical tube which is directly continuous near the lower end of the kidney with the tapering extremity of the renal pelvis. It runs downward and medial ward in front of the Psoas major and, entering the pelvic cavity, finally opens into the fundus of the bladder. The abdominal part (pars abdominalis) lies behind the peritoneum on the medial part of the Psoas major, and is crossed obliquely by the internal spermatic vessels. It enters the pelvic cavity by crossing either the termination of the common, or the commencement of the external, iliac vessels. (7)

At its origin the right ureter is usually covered by the descending part of the duodenum, and in its course downward lies to the right of the inferior vena cava, and is crossed by the right colic and ileocolic vessels, while near the superior aperture of the pelvis it passes behind the lower part of the mesentery and the terminal part of the ileum. The left ureter is crossed by the left colic vessels, and near the superior aperture of the pelvis passes behind the sigmoid colon and its mesentery. (7)

The pelvic part (pars pelvina) runs at first downward on the lateral wall of the pelvic cavity, along the anterior border of the greater sciatic notch and under cover of the peritoneum. It lies in front of the hypogastric artery medial to the obturator nerve and the umbilical, obturator, inferior vesical, and middle hemorrhoidal arteries. Opposite the lower part of the greater sciatic foramen it inclines medial ward, and reaches the lateral angle of the bladder, where it is situated in front of the upper end of the seminal vesicle and at a distance of about 5 cm. from the opposite ureter; here the ductus deferens crosses to its medial side, and the vesical veins surround it. Finally, the ureters run obliquely for about 2 cm. through the wall of the bladder and open by slit-like apertures into the cavity of the viscus at the lateral angles of the trigone. When the bladder is distended the openings of the ureters are about 5 cm. apart, but when it is empty and contracted the distance between them is diminished by one-half.

Owing to their oblique course through the coats of the bladder, the upper and lower walls of the terminal portions of the ureters become closely applied to each other when the viscus is distended, and, acting as valves, prevent regurgitation of urine from the bladder. (7)

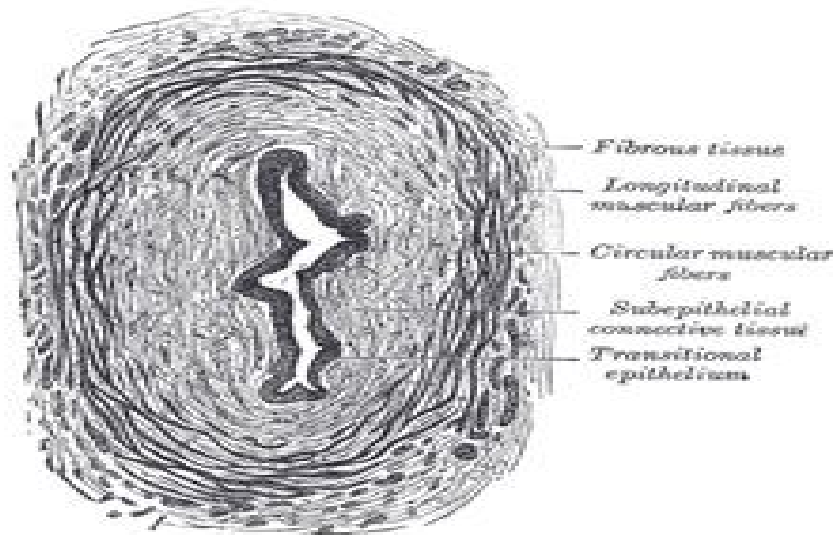


Figure 4 Transverse section of ureter (7)

In the female, the ureter forms, as it lies in relation to the wall of the pelvis, the posterior boundary of a shallow depression named the ovarian fossa, in which the ovary is situated. It then runs medial ward and forward on the lateral aspect of the cervix uteri and upper part of the vagina to reach the fundus of the bladder. In this part of its course it is accompanied for about 2.5 cm. by the uterine artery, which then crosses in front of the ureter and ascends between the two layers of the broad ligament. The ureter is distant about 2 cm. from the side of the cervix of the uterus. The ureter is sometimes duplicated on one or both sides and the two tubes may remain distinct as far as the fundus of the bladder. On rare occasions they open separately into the bladder cavity. (7)

The mucous coat (tunica mucosa) is smooth, and presents a few longitudinal folds which become effaced by distension. It is continuous with the mucous membrane of the bladder below, while it is prolonged over the papillæ of the kidney above. Its epithelium is of a transitional character, and resembles that

found in the bladder. It consists of several layers of cells, of which the innermost—that is to say, the cells in contact with the urine—are somewhat flattened, with concavities on their deep surfaces into which the rounded ends of the cells of the second layer fit. These, the intermediate cells, more or less resemble columnar epithelium, and are pear-shaped, with rounded internal extremities which fit into the concavities of the cells of the first layer, and narrow external extremities which are wedged in between the cells of the third layer. The external or third layer consists of conical or oval cells varying in number in different parts, and presenting processes which extend down into the basement membrane. Beneath the epithelium, and separating it from the muscular coats, is a dense layer of fibrous tissue containing many elastic fibers.

(7)

2-1-2-1 Blood Supply, venous and lymphatic drainage of the ureters

The vascular supply and venous drainage of the ureter is derived from varied and numerous vessels. One critical feature is that the arterial vessels travel longitudinally in the periureteral adventitia. In the abdominal ureter, the arterial supply is located on the medial aspect of the ureter, whereas in the pelvis, the lateral aspect harbors the blood supply . The upper ureter is supplied by the renal artery and by branches from the gonadal artery and aorta. The arterial supply of the middle ureter is derived from the common iliac and gonadal arteries. Finally, the distal ureter is supplied by branches of the common iliac and internal iliac branches, particularly uterine and superior vesical arteries. See the image below, The venous drainage is paired with the arteries. Knowledge of this vascular supply is crucial in ureteral surgery, because a devascularized ureter is subject to complications of stricture and leak. Lymphatic drainage of the upper ureter joins the renal lymphatics to the lumbar nodes. The middle ureter drains to the common and internal iliac nodes. The lymphatic vessels of the pelvic ureter drain to the internal iliac and vesical nodes (2)

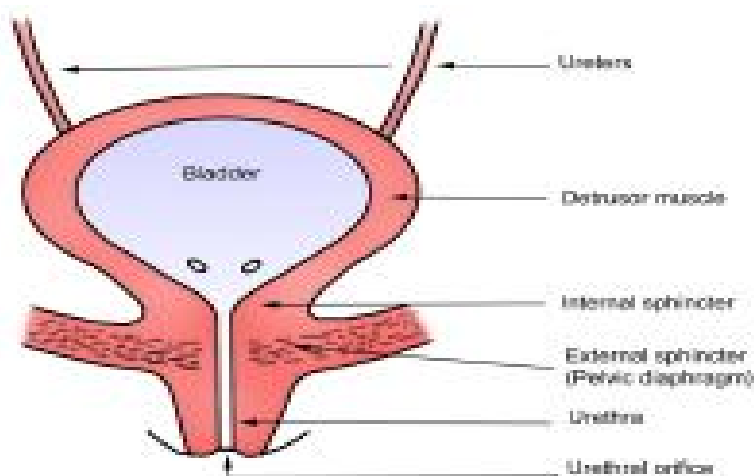
2-1-2-2 Ureteric innervations

The ureter has an intrinsic pacemaker that governs peristalsis but also has autonomic inputs. Thoracolumbar preganglionic inputs synapse with aorticorenal and inferior and superior hypogastric sympathetic plexuses before innervating the ureter. Parasympathetic inputs derive from the S2-S4 segments. Mucosal irritation and luminal distention stimulate nociceptors whose afferents travel with sympathetic nerves and confer the visceral-type referred pain that results in the manifestations of ureteral colic. Pain or hyperesthesia may be sensed from the region of the ipsilateral ribs down to the scrotum or labia (2)

2-1-3 Anatomy of the urinary Bladder

The anatomy of the bladder forms an extraperitoneal muscular urine reservoir that lies behind the pubic symphysis in the pelvis. A normal bladder functions through a complex coordination of musculoskeletal, neurologic, and psychological functions that allow filling and emptying of the bladder contents. The prime effector of continence is the synergic relaxation of detrusor muscles and contraction of the bladder neck and pelvic floor muscles.

Figure 5 (below) **Gross anatomy of the bladder**



The normal adult bladder accommodates 300-600 mL of urine; a central nervous system (CNS) response is usually triggered when the volume reaches

400 mL However, urination can be prevented by cortical suppression of the peripheral nervous system or by voluntary contraction of the external urethral sphincter. The adult bladder is located in the anterior pelvis and is enveloped by extraperitoneal fat and connective tissue. It is separated from the pubic symphysis by an anterior prevesical space known as the retropubic space (of Retzius). The dome of the bladder is covered by peritoneum, and the bladder neck is fixed to neighboring structures by reflections of the pelvic fascia and by true ligaments of the pelvis. (2)

The body of the bladder receives support from the external urethral sphincter muscle and the perineal membrane inferiorly and the obturatorinternus muscles laterally. The bladder wall is made up of muscle fibers extending in all directions. This configuration is well suited to decreasing the bladder size in all dimensions when contracting. The bladder neck serves as an internal sphincter. At the bladder neck, the muscular bladder wall is more organized, and 3 relatively distinct layers become apparent. The inner longitudinal layer fuses with the inner longitudinal layer of the urethra. The middle circular layer is most prominent in the proximity of the bladder neck, and it fuses with the deep trigonal muscle. The outer longitudinal layer contributes some anterior fibers to what become the pubovesical muscles, terminating on the posterior surface of the pubic bone. (2)

These muscles may be important in opening the bladder neck during micturition. Posteriorly, the outer longitudinal fibers interdigitate with deep trigonal fibers and the detrusor muscle. These fibers may aid in bladder neck closure. In males, the bladder neck is contiguous with the prostate, which is attached to the pubis by puboprostatic ligaments. In females, pubourethral ligaments support the bladder neck and urethra. The trigone is a triangular structure formed by the internal urethral opening and the orifices of the right and left ureter. The superior border of the trigone is a raised area called the interureteric ridge. Deep to the mucosa are 2 muscular layers. The superficial layer connects to longitudinal urethral musculature. The deep muscle fuses with detrusor and Waldeyer sheath, the fibromuscular covering of the intramural ureter. The intramural ureter enters the bladder wall obliquely. The muscle fibers are longitudinal in orientation at this point. This segment of the ureter is

about 1.5 cm in length. At the dome of the bladder lies the median umbilical ligament, a fibrous cord that is anchored to the umbilicus. (2)

2-1-3-1 Blood supply of the urinary bladder

The vascular supply to the bladder arrives primarily via the internal iliac (hypogastric) arteries, branching into the umbilical artery that supplies several superior vesicle branches and inferior vesical arteries (which come as direct internal iliac branches in males or from the vaginal arteries in females). The arterial supply also arrives via the obturator and inferior gluteal artery and, in females, via the uterine and vaginal arteries. Bladder venous drainage is a rich network that often parallels the named arterial vessels, most of which ultimately drain into the internal iliac vein. Initial lymphatic drainage from the bladder is primarily into the external iliac, obturator, internal iliac (hypogastric), and common iliac nodes.(2)

2-1-3-2 Innervations of Urinary Bladder

The pelvic plexus is supplying the urinary bladder with autonomic nerves. The sympathetic innervation is directed to the blood vessels, urethral openings, and the trigone. The last thoracic and L 1, 2 nerves create the necessary innervation to the bladder. Parasympathetic innervation is derived from S2, S3 and S4 nerves. These are aimed at serving the detrusor muscle. The pelvic spinal nerves are responsible for responding to the sensory response of a full bladder, which responds to the impulses sent via the central nervous system. (8).

2-1-4 Anatomy of the urethra

The male urethra is 18-20 cm length, running from the bladder to the tip of the penis. The male urethra is supplied by the inferior vesical and middle rectal arteries. The veins follow these blood vessels. The nerve supply is via the pudendal nerve. (9)

In the human female, the urethra is about 1.5 inches (3.8 cm) to 2 inches (5.1 cm) long and exits the body between the clitoris and the vagina, extending from the internal to the external urethral orifice. The meatus is located 1.0-1.5 cm below the clitoris. It is placed behind the symphysis pubis, embedded in the anterior wall of

the vagina, and its direction is obliquely downward and forward; it is slightly curved with the concavity directed forward. Proximal 2/3rd is lined by transitional epithelium while distal 1/3rd is lined by stratified squamous epithelium.^[2] The urethra consists of three coats: muscular, erectile, and mucous, the muscular layer being a continuation of that of the bladder. Between the superior and inferior fascia of the urogenital diaphragm, the female urethra is surrounded by the Sphincter urethrae (urethral sphincter). Somatic (conscious) innervation of the external urethral sphincter is supplied by the pudendal nerve. The uro-genital sinus may be divided into three component parts. The first of these is the cranial portion which is continuous with the allantois and forms the bladder proper. The pelvic part of the sinus forms the prostatic urethra and epithelium as well as the membranous urethra and bulbo urethral glands in the male and the membranous urethra and part of the vagina in females. (10)

2-2 Physiology of urinary system

Excretion of Wastes

The primary function of the kidneys is the excretion of waste products resulting from protein metabolism and muscle contraction. The liver metabolizes dietary proteins to produce energy and produces toxic ammonia as a waste product. The liver is able to convert most of this ammonia into uric acid and urea, which are less toxic to the body. Meanwhile, the muscles of our body use creatinine as an energy source and, in the process, produce the waste product creatinine. Ammonia, uric acid, urea, and creatinine all accumulate in the body over time and need to be removed from circulation to maintain homeostasis.(11)

Filtration, Reabsorption, and Secretion

The kidneys filter blood as it passes through the capillaries that form the glomerulus. Blood pressure forces most of the blood plasma through the lining of the capillaries and into the glomerular capsule. Blood cells are too large to pass through the capillary lining and so remain within the capillaries along with some residual plasma. The filtered plasma, now known as tubular fluid, begins to flow out of the glomerular capsule and into the proximal convoluted tubule and when filtrate reaches the end of the collecting duct, almost all of the valuable nutrients, ions, and water have been returned to the blood supply while waste products and a

small amount of water are left to form urine. The urine exits the collecting duct and joins with urine from other collecting ducts in the renal pelvis. (11)

Water Homeostasis

The kidneys are able to control the volume of water in the body by changing the reabsorption of water by the tubules of the nephron. Under normal conditions, the tubule cells of the nephron tubules reabsorb (via osmosis) nearly all of the water that is filtered into urine by the glomerulus. Water reabsorption leads to very concentrated urine and the conservation of water in the body. The hormones antidiuretic hormone (ADH) and aldosterone both increase the reabsorption of water until almost 100% of the water filtered by the nephron is returned to the blood. ADH stimulates the formation of water channel proteins in the collecting ducts of the nephrons that permit water to pass from urine into the tubule cells and on to the blood. Aldosterone functions by increasing the reabsorption of Na^+ and Cl^- ions, causing more water to move into the blood via osmosis. (11)

In situations where there is too much water present in the blood, our heart secretes the hormone atrial natriuretic peptide (ANP) in order to increase the excretion of Na^+ and Cl^- ions. Increased concentration of Na^+ and Cl^- in urine draws water into the urine via osmosis, increasing the volume of urine produced. (11)

Acid/Base Homeostasis

The kidneys regulate the pH level of the blood by controlling the excretion of hydrogen ions (H^+) and bicarbonate ions (HCO_3^-). Hydrogen ions accumulate when proteins are metabolized in the liver and when carbon dioxide in the blood reacts with water to form carbonic acid (H_2CO_3). Carbonic acid is a weak acid that partially dissociates in water to form hydrogen ions and bicarbonate ions. Both ions are filtered out of the blood in the glomerulus of the kidney, but the tubule cells lining the nephron selectively reabsorb bicarbonate ions while leaving hydrogen ions as a waste product in urine. The tubule cells may also actively secrete additional hydrogen ions into the urine when the blood becomes extremely acidic. (11)

Electrolyte Homeostasis

The kidneys maintain the homeostasis of important electrolytes by controlling their excretion into urine.

Blood Pressure Homeostasis

The kidneys help to control blood pressure in the body by regulating the excretion of sodium ions and water and by producing the enzyme renin. Because blood is mostly made of water, an increased volume of water in the body results in an increase in the volume of blood in the blood vessels. Increased blood volume means that the heart has to pump harder than usual to push blood into vessels that are crowded with excess blood. Thus, increased blood volume leads to increased blood pressure. On the other hand, when the body is dehydrated, the volume of blood and blood pressure decrease. (11)

Hormones

The kidneys maintain a small but important endocrine function by producing the hormones calcitriol and erythropoietin. (11)

2-3 urinary system stone

Kidney stones are small pieces of hard, crystallized material that form in the kidney. Kidney stones are often made up of calcium, but can also contain uric acid or amino acids (proteins) [figure 6]. Kidney stones, also called renal lithiasis, are a common condition. (12)



Figure 6A kidney stone, 8 millimeters (0.31 in) in diameter (13)

One or more kidney stones can form in one or both kidneys. Kidney stones begin as tiny specks and may gradually increase in size. A person with a small kidney stone may not have symptoms and may be unaware of the condition. In some cases, small stones in the urine may pass out of the kidney and move down the ureter, into the bladder, and out of the body without causing pain or serious problems [Figure 7]. (12)

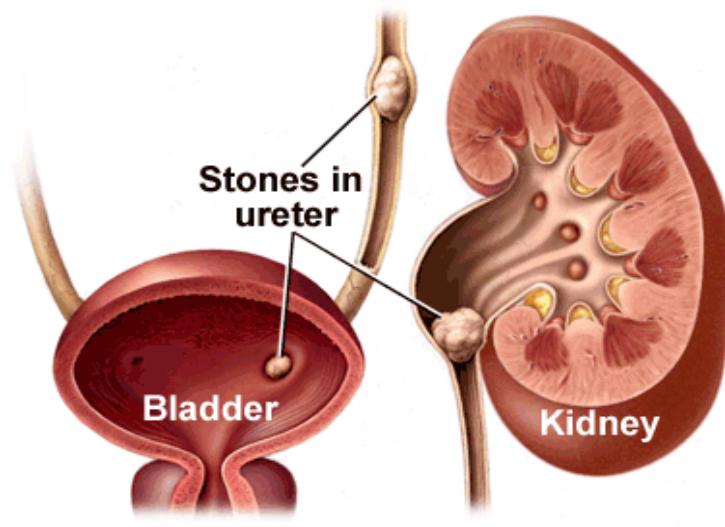


Figure 7 shows kidney, ureter and bladder stones (14)

There are generally no symptoms of a large kidney stone that remains in the kidney. However, when a large kidney stone moves out of the kidney into the ureter toward the bladder, it causes severe flank and abdominal pain, called renal colic. Other symptoms of a large kidney stone that has moved out of the kidney include blood in the urine;, difficulty urinating, and nausea, with or without vomiting. (12)

Kidney stones may be prevented in some cases by ensuring good hydration and with prescribed medication in a high-risk population, such as those with a personal history of kidney stones. Once a stone has developed and causes symptoms, treatment may include hospitalization, pain medication, and certain procedures that remove or crush large stones so that the stone can move more easily out of the body. Small kidney stones may not require treatment. (12)

Most kidney stones pass out of the body in the urine. On occasion, a kidney stone can get stuck in a ureter and result in potentially serious, even life-threatening complications, such as kidney infection and kidney damage. The patient should immediate medical care if the parson with have symptoms of passing a kidney stone, such as severe flank or abdominal pain, not urinating, or bloody urine. Rapid diagnosis and treatment can help reduce the risk of complications. (12)

2-3-1causes urinary system stones

Kidney stones form when there is a decrease in urine volume and/or an excess of stone-forming substances in the urine. The most common type of kidney stone contains calcium in combination with either oxalate or phosphate. Other chemical compounds that can form stones in the urinary tract include uric acid and the amino acid cystine. (15)

Dehydration from reduced fluid intake or strenuous exercise without adequate fluid replacement increases the risk of kidney stones. Obstruction to the flow of urine can also lead to stone formation. In this regard, climate may be a risk factor for kidney stone development, since residents of hot and dry areas are more likely to become dehydrated and susceptible to stone formation. Kidney stones can also result from infection in the urinary tract; these are known as struvite or infection stones. A number of different medical conditions can lead to an increased risk for developing kidney stones include gout results in chronically increased amount of uric acid in the blood and urine and can lead to the formation of uric acid stones. Hypercalciuria. (High calcium in the urine), another inherited condition, causes stones in more than half of cases. In this condition, too much calcium is absorbed from food and excreted into the urine, where it may form calcium phosphate or calcium oxalate stones. Other conditions associated with an increased risk of kidney stones include hyperparathyroidism, kidney diseases such as renal tubular acidosis, and some inherited metabolic bonditions, including cystinuria and hyperoxaluria. Chronic diseases such as diabetes and high blood pressure (hypertension) are also associated with an increased risk of developing kidney

stones. People with inflammatory bowel disease or who have had an intestinal bypass or ostomy surgery are also more likely to develop kidney stones.(**15**)

Some medications also raise the risk of kidney stones; these medications include some diuretics, calcium-containing antacids, and the protease inhibitor indinavir (Crixivan), a drug used to treat HIV infection. Dietary factors and practices may increase the risk of stone formation in susceptible individuals. In particular, inadequate fluid intake predisposes to dehydration, which is a major risk factor for stone formation. Other dietary practices that may increase an individual's risk of forming kidney stones include a high intake of animal protein, a high-salt diet, excessive sugar consumption, excessive vitamin D supplementation, and possible excessive intake of oxalate-containing foods such as spinach. Interestingly, low levels of dietary calcium intake may alter the calcium-oxalate balance and result in the increased excretion of oxalate and a propensity to form oxalate stones. (**15**)

2-3-2Types of urinary system stones

There are different types of kidney stones. Some are made of only one substance and some are made up of a mixture of substances.

A. The most common type of kidney stone contains calcium. Most stones (70 to 80%) contain mainly calcium oxalate crystals. Calcium is a part of a person's normal diet and an important structural and functional element of the body. Calcium that is not used by the bones and muscles goes to the kidneys and flushed out the urine. Excessive calcium in the urine or problems with the body's ability to eliminate calcium can lead to the development of calcium oxalate stones. Too much calcium can be found in the urine because of the use of certain drugs such as diuretics, antacids, and steroids. Overactive parathyroid glands, too much vitamin A or D, and a diet high in purine (or protein) from meat, fish, and poultry can also lead to too much calcium in the urine. Another cause of calcium oxalate stones is too much oxalate in the urine. This can result from too much oxalate production by the body and not enough calcium in the diet. (**16**)

B. A struvite stone forms from an infection in the urinary system. These stones contain the mineral magnesium and the waste product ammonia. This type of stone, also called an infection stone, is more commonly found in women and develops when a urinary tract infection affects the chemical balance of urine. The stones usually develop as jagged structures called staghorns and can grow to be quite large. For patients with struvite stones, it is important not only to remove the stone, but also to prevent recurrence of the urinary tract infection. (16)

C. A uric acid stone may form when there is too much acid in the urine. If the acid level in the urine is high the uric acid normally found in the urine may not dissolve and uric acid stones may form. These stones are more common in men. Patients with gout, a metabolic disorder associated with high uric acid levels, are especially prone to uric acid stones. Different from other types of kidney stones, pure uric acid stones are the only type of stone that can be dissolved with medication. (16)

D. Cystine stones are rare. Cystine is one of the building blocks that make up muscles, nerves, and other parts of the body. It is an amino acid and protein that does not dissolve well. Some people inherit a rare condition that results in large amounts of cystine in the urine. This condition, called cystinuria, causes cystine stones that are difficult to treat and requires long-life therapy. (16)

2-3-3 Diagnosis of urinary system stones

Doctors usually suspect stones in people with renal colic. Sometimes doctors suspect stones in people with tenderness over the back and groin or pain in the genital area without an obvious cause. Finding blood in the urine supports the diagnosis. Occasionally, the symptoms and physical examination findings are so distinctive that no additional tests are needed, particularly in people who have had urinary tract stones before. However, most people are in so much pain and have symptoms and findings that make other causes for the pain seem likely enough that testing is necessary to exclude these other causes. (17)

Helical (also called spiral) computed tomography (CT) that is done without the use of radiopaque contrast material is usually the best diagnostic procedure. CT can locate a stone and also indicate the degree to which the stone is blocking the

urinary tract. CT can also detect many other disorders that can cause pain similar to the pain caused by stones. The main disadvantage of CT is that it exposes people to radiation. Still, this risk seems prudent when possible causes include another serious disorder that would be diagnosed by CT, such as an aortic aneurysm or appendicitis. Newer CT devices that limit exposure to radiation are sometimes used. (17)

Ultrasonography is an alternative to CT and does not expose people to radiation. However, ultrasonography, compared with CT, more often misses small stones (especially when located in the ureter), the location of urinary tract blockage, and other, serious disorders that could be causing the symptoms. (17)

X-rays of the abdomen expose people to much less radiation than does CT, but x-rays are much less accurate in diagnosing stones and can only show calcium stones. When doctors suspect the person has a calcium stone, x-rays are an alternative to confirm the presence of a stone or to see how far a stone has travelled. (17)

Excretory urography (previously called intravenous urography or intravenous pyelography) is a series of x-rays taken after intravenous injection of a radiopaque dye. This test can detect stones and accurately determine the degree to which they are blocking the urinary tract, but it is time-consuming and involves the risks of exposure to the dye (for example, an allergic reaction or worsening of kidney failure). Excretory urography is rarely used if CT or ultrasonography is available. (17)

Urinalysis is usually done. It may show blood or pus in the urine whether or not symptoms are present. (17)

For people with diagnosed stones, doctors often do tests to determine the type of stones. People should attempt to retrieve stones that are passed. They can retrieve stones by straining all urine through a paper or mesh filter. Stones found can be analyzed. Depending on the type of stone, urine tests and tests to measure levels of calcium, hormones, and other substances in the blood may be necessary. (17)

2-3-4 Imaging studies

2-3-4-1 Ultrasound imaging

Ultrasound imaging of the kidneys can sometimes be useful as it gives details about the presence of hydronephrosis, suggesting the stone is blocking the outflow of urine. Radiolucent stones, which do not appear on CT scans, may show up on ultrasound imaging studies. Other advantages of renal ultrasonography include its low cost and absence of radiation exposure. Ultrasound imaging is useful for detecting stones in situations where x-rays or CT scans are discouraged, such as in children or pregnant women. Despite these advantages, renal ultrasonography is not currently considered a substitute for non-contrast helical CT scan in the initial diagnostic evaluation of urolithiasis. The main reason for this is that compared with CT, renal ultrasonography more often fails to detect small stones (especially ureteral stones) as well as other serious disorders that could be causing the symptoms. (18)

2-3-4-2 KUB

A kidney, ureter, and bladder (KUB) X-ray may be performed to assess the abdominal area for causes of abdominal pain, or to assess the organs and structures of the urinary and/or gastrointestinal (GI) system. A KUB X-ray may be the first diagnostic procedure used to assess the urinary system. (19)

X-rays use invisible electromagnetic energy beams to produce images of internal tissues, bones, and organs on film. X-rays are made by using external radiation to produce images of the body, its organs, and other internal structures for diagnostic purposes. X-rays pass through body tissues onto specially treated plates (similar to camera film) and a "negative" type picture is made (the more solid a structure is, the whiter it appears on the film).(19)

Calcium-containing stones are relatively radio dense, and they can often be detected by a traditional radiograph of the abdomen that includes the kidneys, ureters, and bladder (KUB film). Some 60% of all renal stones are radiopaque. In general, calcium phosphate stones have the greatest density, followed by calcium

oxalate and magnesium ammonium phosphate stones. Cystine calculi are only faintly radio dense, while uric acid stones are usually entirely radiolucent [figure 8]. (18)



Figure 8 a. bilateral kidney stones can be seen on this KUB radiograph (19). Note the presence of phieboliths in the pelvis, which can be misinterpreted as bladder stones. B.contrast IVU(18)

2-3-4-3 Intravenous pyelogram (IVP)

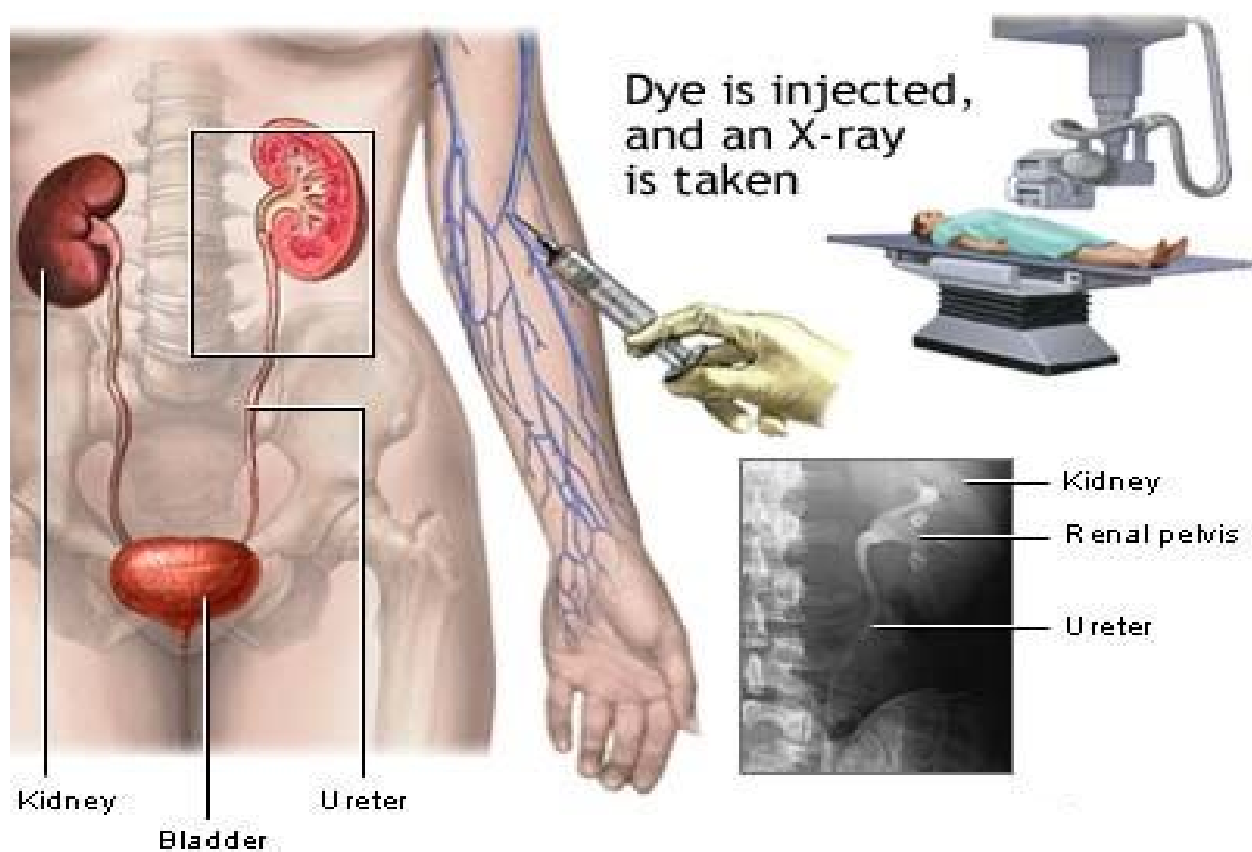


Figure 9 In the procedure intravenous pyelogram (IVP), the patient is injected with dye. X-ray is taken as the dye travels through the urinary tract. This procedure is done to confirm the presence of kidney stones, although some stones may be too small to see. (21)

Where CT scan is unavailable, an intravenous pyelogram (IVP) may be performed to help confirm the diagnosis of urolithiasis. The IVP involves intravenous injection of a contrast agent followed by serial films. Urolithiasis present in the kidneys, ureters or bladder may be better defined by the use of this contrast agent.

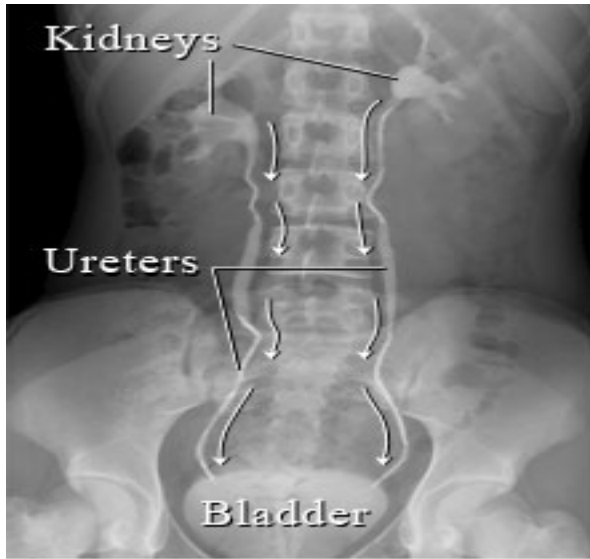


Figure 1

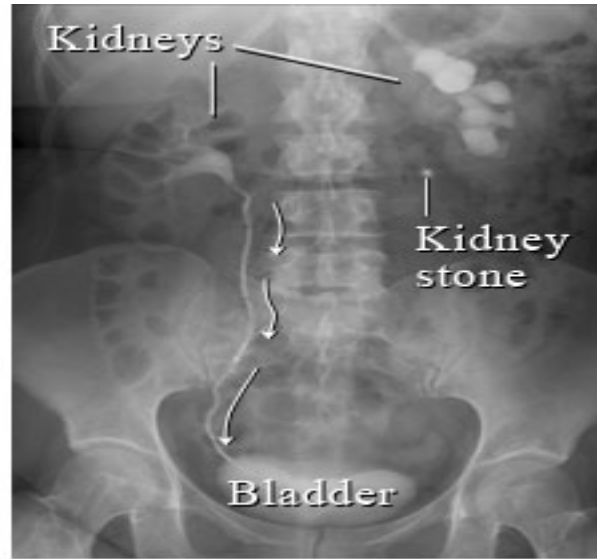


Figure 2

Figure 10 show an X-ray with contrast dye (intravenous pyelogram, or IVP) of the kidneys, ureters, and bladder. Figure (1) shows a normal flow from the kidneys, through the ureters, to the bladder (white arrows). Figure (2) shows a kidney stone blocking the normal flow of urine in the ureter on the right. (23)

2-3-4-4 CT scan

This is one of the best methods to detect kidney stones, especially when someone comes to the emergency room with severe pain (colic) due to a passing stone. It is more sensitive than ultrasound or x-ray. It is performed by placing the patient in an x-ray tube that creates several images of the kidneys, ureter, and bladder. It can detect both calcium and non-calcium stone. Although it may sometimes miss crivivan/indinavir stones. It is more expensive than an x-ray and requires more radiation. Since it scans many organs, it can sometimes detect non stone causes of severe pain. (24)

CT scans of the kidneys can provide more detailed information about the kidneys than standard kidneys, ureters, and bladder (KUB) X-rays, thus providing more information related to injuries and/or diseases of the kidneys. CT scans of the

kidneys are useful in the examination of one or both of the kidneys to detect conditions such as tumors or other lesions, obstructive conditions, such as kidney stones, congenital anomalies, polycystic kidney disease, accumulation of fluid around the kidneys, and the location of abscesses. (25)

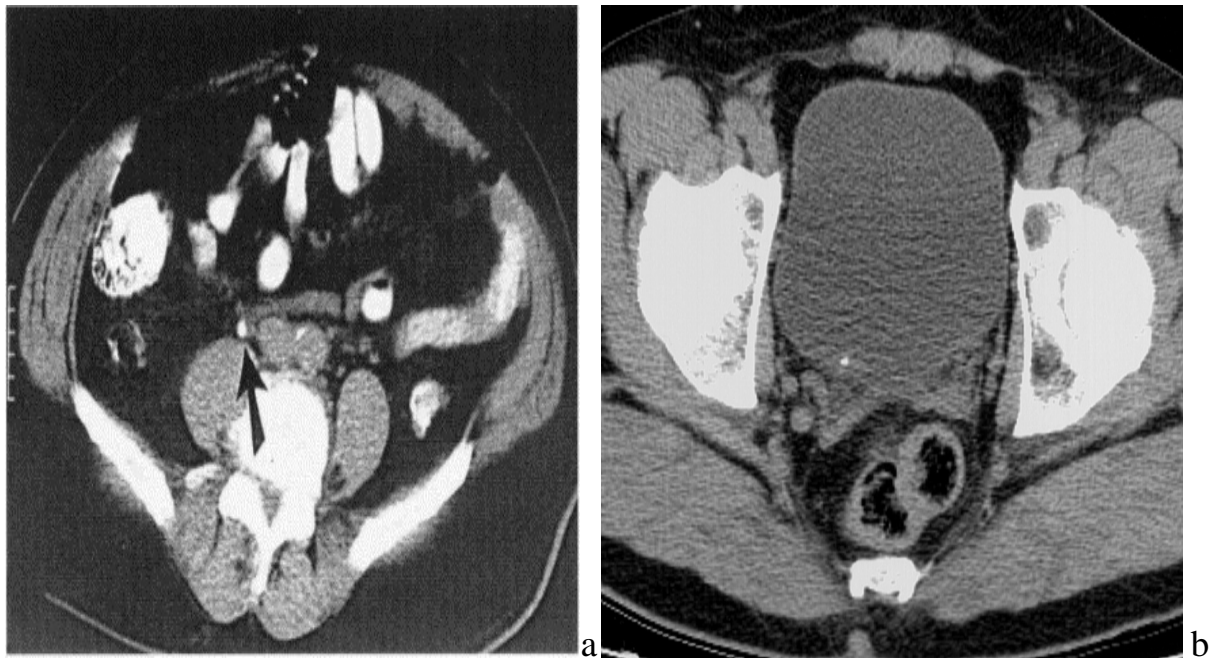


Figure 11

a. Axial CT scan of abdomen without contrast, showing 3mm stone (marked by an arrow) in the right proximal ureter (25)

b. Axial CT scan of abdomen without contrast shows a stone at the ureterovesical junction (25)

2-3-4-5 Magnetic Resonance Imaging

Magnetic resonance imaging (MRI) techniques are showing promise for diagnosing urinary tract obstruction but do not yet accurately reveal small stones, or ones that do not cause a blockage. Because no radiation is involved with MRI, however, it may prove to be a good option for pregnant women. (26)

2-3-4-6 Urine Tests

Urine samples are required to evaluate features of the urine, including its acidity and the presence of Red or white blood cells, infection crystals, high or low levels of chemicals that inhibit or promote stone formation. (25)

2-4 Indications of CT KUB

A CT scan of the kidney may be performed to assess the kidneys for tumors and other lesions, obstructions such as kidney stones, abscesses, polycystic kidney disease, and congenital anomalies, particularly when another type of examination, such as x-rays or physical examination, is not conclusive. CT scans of the kidney may be used to evaluate the retro-peritoneum (the back portion of the abdomen behind the peritoneal membrane). CT scans of the kidney may be used to assist in needle placement in kidney biopsies (26)

After the removal of a kidney, CT scans may be used to locate abnormal masses in the empty space where the kidney once was. CT scans of the kidneys may be performed after kidney transplants to evaluate the size and location of the new kidney in relation to the bladder. (26)

2-5 Basic Patient Position

The patient lies supine on the table, Median sagittal plane aligned to the center;the knees can be flexed at 45 degrees and supported for comfort, the arms placed alongside the trunk or above the head. (27)

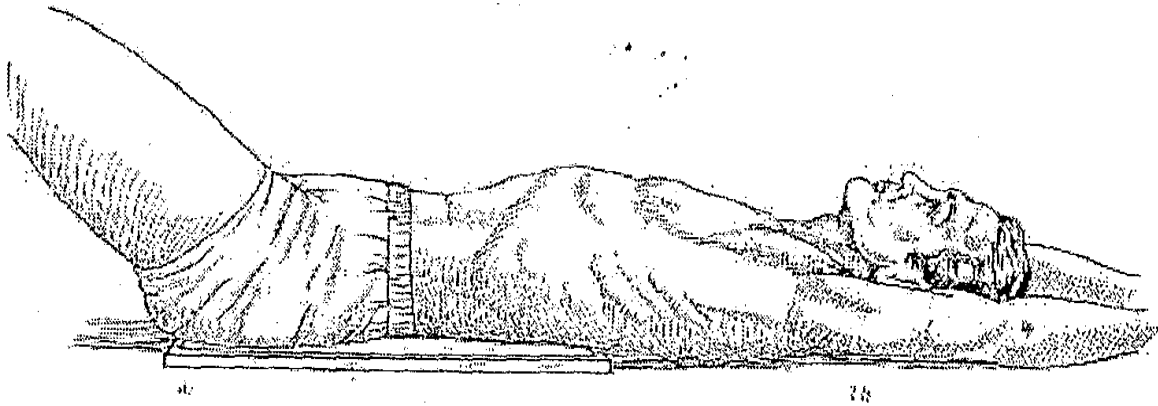


Figure 12 Patient positions for abdomen CT study (27)

2-5-1 Radiation protection

Direct lead rubber gonad protection in males, 10 day rule for females where appropriate (27)

2-5-2 Central Ray

The vertical central ray is centered in the midline at the level of the iliac crests. (27)

2-5-3 Risks of the Procedure

Risks associated with radiation exposure may be related to the cumulative number of x-ray examinations and/or treatments over a long period of time. (26)

In case of pregnancy or suspect that, this may be more risk for Radiation exposure, which may lead to birth defects. (26)

When contrast dye is used, there is a risk for allergic reaction to the dye. Patients who are allergic to or sensitive to medications, contrast dye, or iodine should notify their physician. Studies show that eighty-five percent of the population will not experience an adverse reaction from iodinated contrast; however, the technologist should know if the patients have ever had a reaction to any contrast dye, and/or any kidney problems. A reported seafood allergy is not considered to be a contraindication for iodinated contrast. (26)

Other risk factor is associated with I.V contrast media the contrast dye can cause kidney failure, especially if the person is taking Glucophage (a medication used to treat diabetes). The effects of kidney disease and contrast agents have attracted increased attention over the last decade, as patients with kidney disease are more prone to kidney damage after contrast exposure. (26)

Certain factors or conditions may interfere with the accuracy of a CT scan of the kidney. These factors include, but are not limited to, the metallic objects within the abdomen, such as surgical clips, barium in the intestines from a recent barium study, recent tests involving dye or other foreign substances. (26)

2.6 previous studies

Departments of Urology and Radiology (JSC, JPR), Children's Hospital Boston, Boston, Massachusetts

Purpose: We prospectively evaluated the precision of ultrasound and computerized tomography to diagnose pelvicalyceal system stones in children and determined whether these differences in radiological findings have any impact on clinical management.

Materials and Methods: A total of 50 consecutive patients with suspected urolithiasis underwent computerized tomography and ultrasound. Two radiologists reviewed each study independently in blinded fashion. When a difference in findings was detected, 8 pediatric urologists reviewed the case. Clinical management was based on the results of each radiological test independently. Statistical analysis was performed using Fisher's exact test.

Conclusions: Although computerized tomography is more sensitive for detecting urolithiasis than ultrasound, the difference in usefulness between the 2 radiological tests may not be clinically significant. Given concerns for the potentially harmful cumulative long-term effect of radiation, ultrasound should be considered the first imaging test in children with suspected urolithiasis.

keir A. B. Fowler, MD, Julie A. Locken, MD, Joshua H. Duchesne, and Michael R. Williamson, MD

Purpos: To determine the sensitivity and specificity of ultrasonography (US) for detecting renal pelvis calculi and to establish the accuracy of US for determining the size and number of calculi.

Material and methods : A total of 123 US and computed tomographic (CT) examinations were compared retrospectively for the presence of renal calculi. The sensitivity of US was determined for individual calculi and at least one calculus per examination. Retrospective findings were compared with the original US interpretation. The sizes of calculi in longest axis were compared on US and CT images, and the US detection of calculi in the left and right kidneys was compared.

was concordant in 79% of cases and differed by a mean of $1.5 \text{ mm} \pm 0.7$.

Conclusion: US is of limited value for detecting pelvicalyceal system calculi.

Chapter Three

Material and methods

3-1 Material

3-1-1 Patient

50 patients, with age ranging from (20-75) years old, 17 females and 33 males underwent US and CT- KUB to assess pelvicalyceal system stones, this study was done on May 2017 to December 2017, and the data were collected from Yastebshiroon hospital.

3-1-2 Machine used

- CT scan machine Toshiba 16 slices, the parameters which are used shown in the table below:

Table 3-1 parameters are used:

Parameter	Toshiba16 slices
Kvp	120
MAS	150
Slice thickness	8mm
Beam collimation	0.8*16mm
Time per rotation	0.65/0.5mm

3-2 Methods

3-2-1 Technique

All Patient underwent CT scan for KUB.

In CT scan patients positioned in supine, head first, the arms were raised and placed behind the patients head(out of the scan plane), positioning was added by alignment lights, the median sagittal plane was perpendicular and the coronal plane is parallel to the scanner table top, the scanner table height was adjusted to ensure that the coronal plane alignment was at the level of mid axillary line. The patient was move in to the scanner until the scan reference point was at the level of the xiphoid process. All images were done without contrast media. The scout view was obtained to include the diaphragm and pubis, with slice thickness (3-5)mm, without patient preparation and by using 120 KvP and (140-160)MAS, and then Trans axial images were taken during normal respiration. Although married female patient must ensure that 28 day rule where appropriate.

- **Slice thickness:** was from (3 to 5mm)
- **Scan time:** was from (10 to 15 min)

3-2-2 image interpretation

All images were studied by technologist starting by abdominal ultrasound as primary screening tools then all first patients studded by CT-KUB and the following data were collected from their images: location, size and CT number of stones were measured by computer program in the CT. diagnosis were seen from the radiologist reports.

3-3 Data analysis

The collected data was analyzed statistically by excel.

Chapter Four

Results

The following tables and figures presented the data including the sample gender, mean age, stone location according to the site either in the right kidneys, It kidney, stone mean length, width, area, as well as the mean CT number(HU).

Table 4.1 the sample including male and female in percentage:

Gender	Number	Percentage
Male	36	72%
Female	14	28%
Total	50	100%

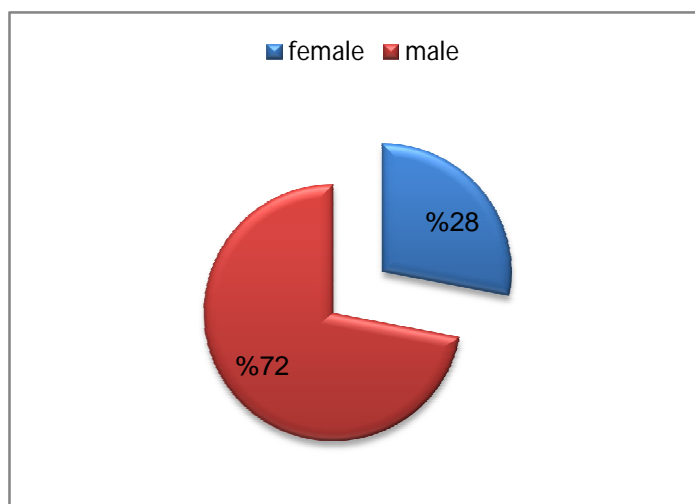


Figure 4.1 Adialogram shows the gender distribution.

Table 4.2 The age distribution

Age	20-30	31-40	41-50	51-60	61-70	71-80	Total
Number	16	3	6	13	8	4	50
Percentage	32%	6%	12%	26%	16%	8%	100%

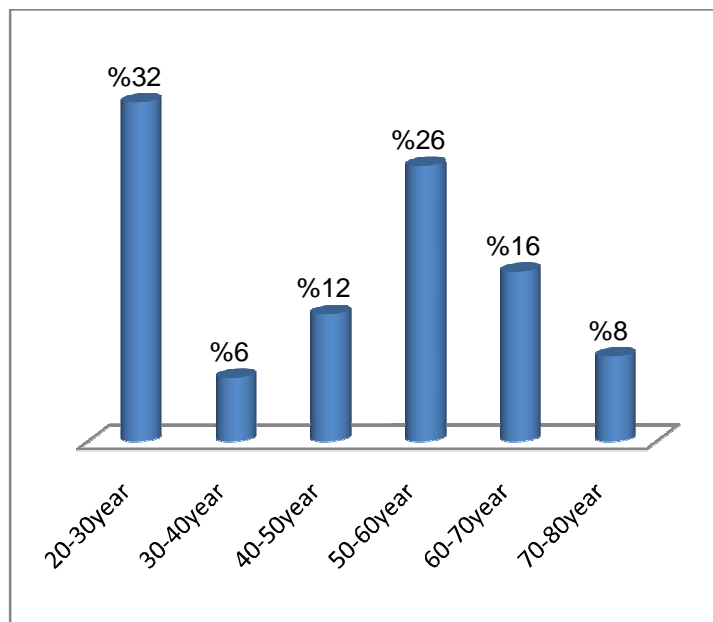


Figure 4.2A diagram shows the correlation between the age and the stone formation.

Table 4.3The presentation of the stones according to the sites.

Location	Number	Percentage
Rt Kidney	32	64%
Lt Kidney	18	36%

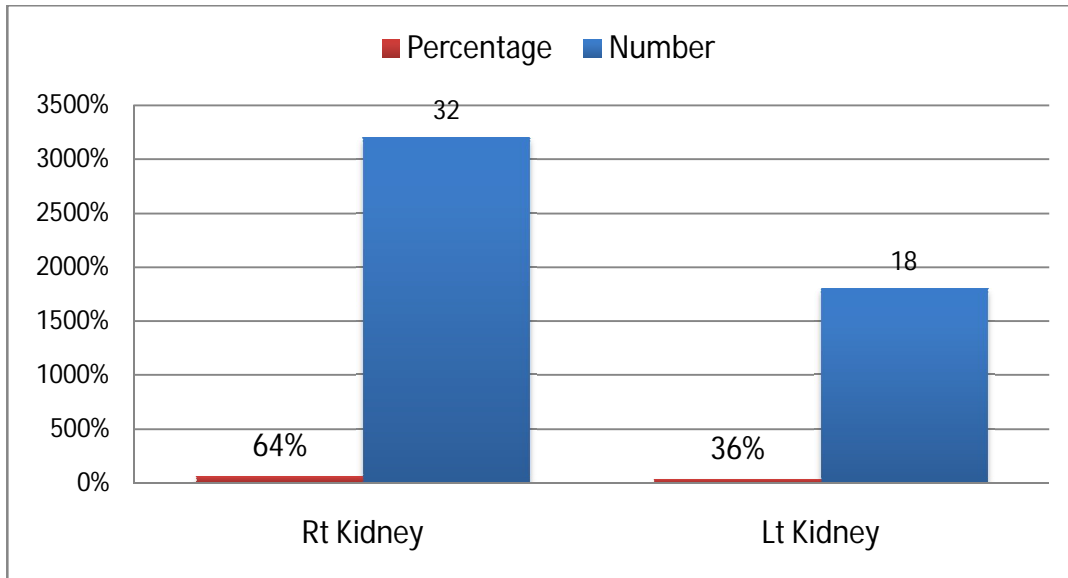


Table 4.4 The size of the stones.

size	0.5-1mm	2-5mm	6-9mm	10-13mm	14-17mm	18-21mm	Total
Number	2	13	21	9	3	2	50
Percentage	4%	26%	42%	18%	6%	4%	100%

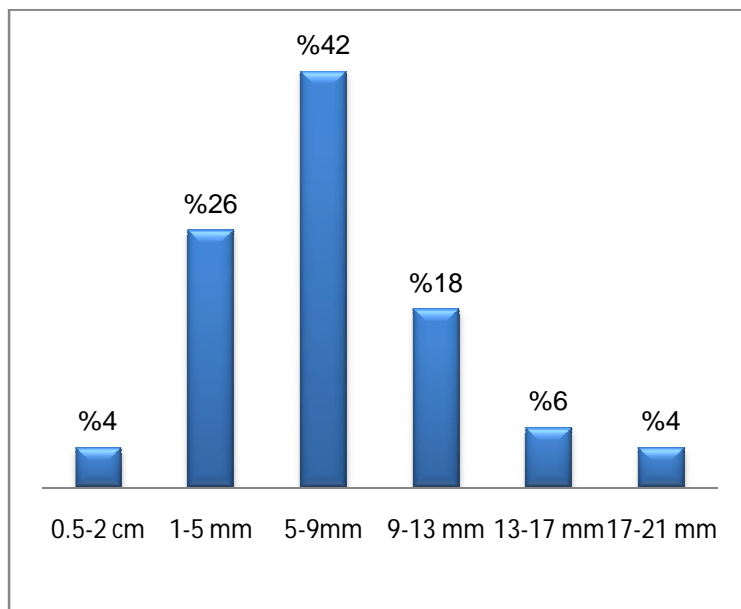


Figure 4.4A diagram shows the size of the stones.

Table 4.5 The density of the stones:

Density	200-500HU	501-800HU	801-1100HU	1101-1400HU	1401-1700HU	Total
Number	20	16	9	2	3	50
percentage	40%	32%	18%	4%	6%	100%

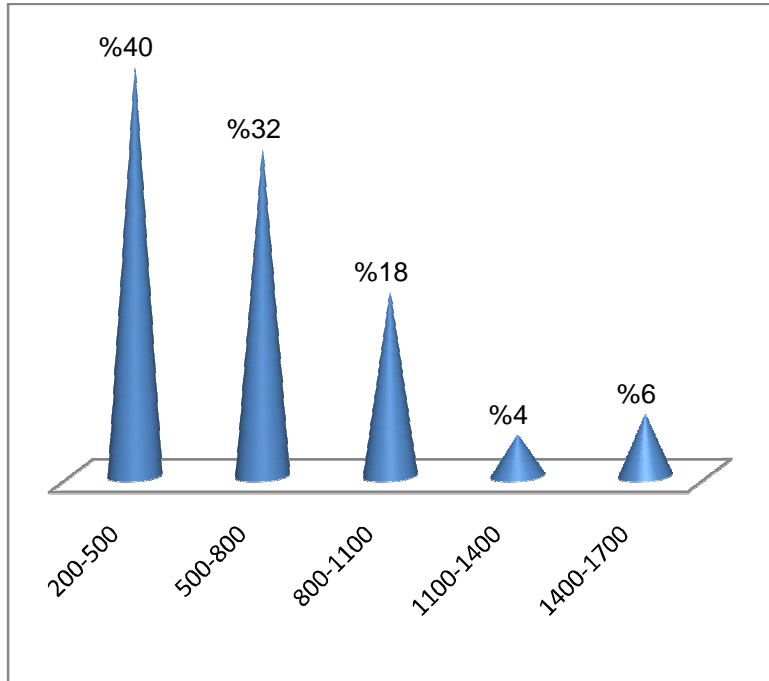


Figure 4.5A diagram shows the density of the stones.

The colorations between the age and stones size shows Correlation Coefficient 0.934 and the colorations between the stone density and stones size shows Correlation Coefficient 0.920.

Chapter Five

5-1 Discussion

This study showed that males were more affected with pelvicalyceal system stones than females (72% of the patients were males and 28% of the patients were female).and the age range between 20–80 years, and the female age range between 30–65 years. The young male were more affected then young femals.

The study showed that most pelvicalyceal system stone were located in right kidney than the left kidney (32 of the sample in right kidney (64%), and 18 of the sample in the left kidney (36%)).

The accuracy of CT-KUB calculated and equal 100%, and the sensitivity of CT-KUB 100%.

The study showed that CT-KUB can detect small stones without magnification.

5-2 Conclusion

From these results, the study concluded the following:

- Male has more potential to get pelvicalyceal system stone than female.
- In this study the type of stones are determined by CT-KUB.
- US can be used to measure the pelvicalyceal system stones.
- CT scans can be used to measure the pelvicalyceal system stones.

5-3 Recommendation

1-After every negative ultrasounds scan and clinical position patient should do the CT-KUB for accurate treatment.

2-CT-KUB should be available in hospitals to enhance detection rate of small renal stones.

3- Training of the radiology technologist about the uses and technique of renal scan.

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Appendices

Data Sheet

Patient	Gander	Age	Location	Size of the stone in CT-KUB(cm)	CT number (HU)
1	F	30	RT kidney	0.19	1500
2	M	72	RT kidney	1.0	1000
3	M	43	LT kidney	0.29	84
4	F	60	RT kidney	0.16	1334
5	M	70	LT kidney	0.18	1466
6	M	20	RT kidney	1.1	507
7	F	31	RT kidney	0.62	645
8	M	27	LT kidney	1.1	963
9	M	47	RT kidney	0.99	1176
10	M	37	RT kidney	0.99	254
11	M	10	RT kidney	0.65	681
12	M	6	LT kidney	0.63	102

Data Sheet

Patient	Gander	Age	Location	Size of the stone in CT-KUB(cm)	CT number (HU)
13	M	30	LT kidney	0.84	373
14	M	52	RT kidney	0.76	271
15	F	45	LT kidney	0.85	339
16	M	80	LT kidney	0.64	229
17	M	65	LT kidney	0.37	100
18	F	27	RT kidney	0.93	603
19	M	37	RT kidney	0.87	500
20	M	40	LT kidney	0.96	400
21	M	50	RT kidney	0.55	804
22	M	35	LT kidney	0.26	313
23	M	28	RT kidney	1.1	1357

Data Sheet

Patient	Gander	Age	Location	Size of the stone in CT-KUB(cm)	CT number (HU)
24	M	69	RT kidney	0.87	250
25	M	40	LT kidney	0.85	300
26	M	70	LT kidney	1.0	200
27	F	65	LT kidney	1.2	225
28	F	37	RT kidney	0.55	494
29	F	20	LT kidney	0.65	753
30	M	29	RT kidney	0.59	1200
31	F	35	LT kidney	1.1	200
32	F	38	RT kidney	1.2	270
33	M	40	LT kidney	1.2	380
34	M	40	RT kidney	0.89	702
35	M	5	RT kidney	0.35	324

Data Sheet

Patient	Gander	Age	Location	Size of the stone in CT-KUB(cm)	CT number (HU)
36	M	35	LT kidney	0.41	1238
37	M	37	LT kidney	0.34	1018
38	M	28	RT kidney	0.93	1560
39	M	32	RT kidney	0.62	1008
40	M	29	RT kidney	1.0	1049
41	M	78	RT kidney	0.31	756
42	F	58	RT kidney	0.32	200
43	M	9	RT kidney	0.64	600
44	M	6	RT kidney	0.61	242
45	F	19	RT kidney	0.71	650
46	F	41	RT kidney	1.2	224
47	F	67	RT kidney	1.1	195
48	M	44	RT kidney	1.3	989
49	F	25	RT kidney	0.95	597
50	M	56	RT kidney	0.92	139