

URINARY TRACT CALCULI

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INTRODUCTION

Imaging plays an essential role in the diagnosis and initial management of urolithiasis. The imaging methods used have undergone considerable evolution in recent years. One major advance is the use of *non-contrast helical computed tomography* (NCHCT) in patients who have suspected renal colic. This article reviews various aspects regarding the formation, diagnosis, and management of urolithiasis.

TERMINOLOGY

The terms *kidney stones*, *renal stones*, *renal calculi*, *nephrolithiasis*, and *urolithiasis* are often used interchangeably to refer to the gravel-like deposits that may appear in any part of the urinary system, from the kidney to the bladder. These deposits may be small or large, single or multiple. Sometimes they are no bigger than a sugar granule, whereas in other cases they're so large that they fill the entire renal pelvis. The term *nephrolithiasis* is derived from the Greek *nephros* (kidney) and *lithos* (stone). Urolithiasis stems from the Latin word *urina* (urine) and the Greek term *ouron* (stone). The term *calculus* (pleural, calculi) is the Latin word for pebble. Specifically, the term *renal calculi* is used to describe stones that are located in the kidney, whereas *ureterolithiasis* refers to stones that are in a ureter.

The passage of renal calculi from the kidney through the urinary tract is frequently accompanied by acute pain that's referred to as renal colic. Ureteral stones can sometimes cause ureteral obstruction resulting in dilatation, distention, and enlargement of the collection system in the kidney; these changes are collectively referred to as *hydronephrosis*. However, urinary tract stones are not always painful and sometimes remain undetected for

many years. In some cases, stones are discovered as an incidental finding when a patient undergoes ultrasound or x-ray examinations for unrelated conditions.

HISTORICAL PERSPECTIVE

Unlike many other medical conditions such as diverticulitis, kidney stones are not a result of modern lifestyles. In fact, stone disease can be traced back to the earliest human records. Scientists have found evidence of kidney stones in a 7000-year-old Egyptian mummy.¹ Historically, a variety of methods have been used to treat urinary calculi; these methods have ranged from magical spells to crushing stones (ie, the earliest form of lithotripsy) using a diamond head attached to the end of a metal shaft.² The procedure ancient Egyptians used to remove stones has been described by medical historians: "The urethra was dilated by a wooden or cartilaginous cannula as thick as the thumb pushed in with great force alternating with blowing down the urethra; the stone was pressed down into the perineum by the fingers in the rectum until it could be reached from the urethra, or sucked out by the mouth."³ Fortunately, great strides have been made in the diagnosis and management of urinary calculi.

EPIDEMIOLOGY

The incidence of nephrolithiasis is slightly more than 1 case per 1000 patients per year and has been slowly increasing in recent decades.⁴ The National Institutes of Health estimate that 10% of people in the United States will have a kidney stone at some point in their lives.¹ Kidney stones are most common in middle-aged people, with peak onset in the fourth decade of life. These stones are three times more common in men than in women.⁵ Whites are affected more often than persons of Asian ethnicity, who are affected more often than blacks. In addition, urolithiasis occurs more frequently in hot, arid areas than in temperate regions.^{1,6} This geographic propensity is thought to be linked to the likelihood of dehydration and consequent increased urine concentration that are important factors influencing stone formation. Kidney stones tend to recur. Approximately 50% of patients with previous urinary calculi have a recurrence within 10 years.⁶ In the United States, urinary stones

account for more than 1.3 million doctor visits each year; total direct and indirect costs top \$1.83 billion.¹

CAUSES

When there is no clear precipitating factor identified that can be linked to stone formation, the condition is referred to as idiopathic nephrolithiasis. Urinary tract infection and kidney disorders such as polycystic kidney disease are associated with stone formation. A number of metabolic diseases are associated with nephrolithiasis (eg, hyperparathyroidism, hyperoxaluria). In general, the development of stones is related to decreased urine volume or increased excretion of stone-forming components such as calcium, oxalate, urate, cystine, xanthine, and phosphate. The stones form in the urine-collecting area (ie, the pelvis) of the kidney. For many patients, hereditary factors are important. A person with a family history of kidney stones is more likely to develop stones. Genetic factors may play a role in up to 45% of calcium stone cases.⁷

Normal urine is supersaturated with calcium oxalate, the primary constituent of most kidney stones. However, stones will not form unless there is one of a number of abnormalities such as overexcretion of stone constituents, a persistent imbalance in urinary pH, or an obstruction in the urinary tract. In some cases, the underlying problem is simply poor fluid intake leading to concentrated urine.⁸

Although certain foods may promote stone formation in people who are susceptible, researchers do not believe that eating any specific food causes stones to form in people who are not susceptible.¹ Therefore, there are no specific dietary recommendations to prevent stone formation. However, once a stone has been analyzed, the patient's diet can be evaluated, and then changes can be recommended that will reduce the likelihood of recurrence.

TYPES OF STONES

Stone composition often provides clues to the underlying metabolic abnormality. There are four main types of urinary stones: calcium salts, uric acid, magnesium ammonium phosphate (called struvite), or cystine (Table 1). A fifth type is called indinavir stones. These stones appear in patients with human immunodeficiency virus infection who are treated with the protease inhibitor indinavir.

TABLE 1. Types and Percentage Composition of Renal Stones*

Type	Percentage
Calcium salts Calcium oxalate Calcium phosphate Calcium urate	75
Struvite	15
Uric acid	6
Cystine	2
Indinavir stones	< 1

*Reprinted with permission from Craig S. Renal calculi. Available at: <http://www.emedicine.com/emerg/topic499.htm>. Accessed 10/14/03.

CALCIUM SALT STONES

Calcium stones are the most common type of stone, accounting for approximately 75% of stone cases. They occur when there is too much calcium in the urine or blood. There are a variety of conditions that result in excessive urine calcium (hypercalciuria) or excessive blood calcium (hypercalcemia). Defective kidney function may allow too much calcium in the urine, or excessive calcium may be absorbed from the stomach and intestines. Some calcium stones are caused by an excess of a chemical called oxalate that is present in many foods such as spinach or chocolate. Oxalate binds easily with the calcium to form a stone. It is interesting to note that excessive dietary calcium is not thought to be a factor in stone formation, so calcium restriction is no longer recommended.⁶ Calcium stones are caused by the following conditions:

HYPERCALCIURIA

This condition is responsible for approximately 70% of calcium-combining stones.⁷ The following disorders are associated with the formation of stones composed of calcium salts attributable to hypercalciuria:

Increased gut absorption of calcium. In more than half of cases, the source of excess calcium in urine is from the intestine, not the kidney.⁷ In most cases, a combination of genetic factors work together to increase calcium absorption. Researchers are investigating a number of suspects, including a possible defective gene that regulates calcitriol, a form of vitamin D that in excessive levels may increase intestinal absorption of calcium.

Excessive chloride levels. The body often uses chloride, which has a negative charge, to balance calcium, which has a positive charge. Therefore, excessive chloride levels may lead to excessive calcium levels. A gene known as CLCN5, which regulates chloride in the urine, is defective in many patients who have calcium stones.

Renal calcium leak. This is a condition in which the filtering processes in the kidney fail, causing increased levels of calcium in the urine.

Excessive sodium. Calcium absorption in the kidney tubules follows the absorption of sodium and water. Thus, high urinary levels of sodium result in increased urinary levels of calcium. Defects in the kidney tubule transport system can cause imbalances in sodium and phosphate that result in elevated calcium levels in the urine. A high-salt diet can also produce this effect.

HYPERCALCEMIA

In general, hypercalcemia occurs when bones break down and release too much calcium into the bloodstream. This process, called resorption, can occur for any of the following reasons:

Hyperparathyroidism. This condition is due to increased activity of the parathyroid gland that results in overproduction of parathyroid hormone. Hyperparathyroidism is more prevalent in women than men, and most commonly affects people 50 to 60 years old. Parathyroid hormone helps regulate calcium and phosphorous levels in the body. Normally, the parathyroid glands produce this hormone in response to the body's demand for calcium associated with maintaining adequate bone mass, pregnancy, or lactation. However, when one or more parathyroid glands malfunction, overproduction of the hormone and consequent elevated calcium levels in the blood may occur.

Immobilization. Any condition in which a person is immobilized for long periods of time, such as is the case with paraplegics, can lead to hypercalcemia due to bone loss.

Renal tubular acidosis. This disorder causes an acid and alkaline imbalance that increases calcium levels and reduces citrate levels in the blood.

Excessive intake of vitamin D. This condition can increase intestinal absorption of calcium. During therapy for peptic ulcers, abnormally high amounts of calcium antacid are sometimes taken. This can result in a chronic disorder of the kidney referred to as milk-alkali syndrome that results in hypercalcemia. Conditions such as Paget's disease, in which bone is destroyed or reabsorbed, can also cause hypercalcemia.

HYPEROXALURIA

Oxalate (also called oxalic acid) combines with calcium to form calcium oxalate, which is a common stone-forming compound. Excessive oxalate in the urine is called hyperoxaluria, which is responsible for approximately 30% of calcium stones.⁷ The following conditions are associated with hyperoxaluria:

- *Primary hyperoxaluria*—an inherited disorder
- *Deficiencies of vitamin B⁶*—Severe vitamin B⁶ deficiencies, usually due to a genetic disorder, can result in the overproduction of oxalic acid.

- *Short bowel syndrome*—This condition is characterized by inadequate absorption of ingested nutrients due to surgery in the small intestine. With this disorder, the intestines are unable to absorb fat and other nutrients. In such cases, calcium may bind to unabsorbed fat instead of oxalates, which creates excessive levels of oxalates that are then excreted into the kidney. People with Crohn's disease and intestinal infections as well as children with structural abnormalities in the small intestine may need the type of surgery that can result in short bowel syndrome.

HYPOCITRURIA

Citrate is the primary agent for the removal of excess calcium. Low citrate levels in the urine, known as hypocitruria, are a significant risk factor for the formation of calcium (and also uric acid) stones. Although many conditions can reduce citrate levels, the factors that can cause hypocitruria severe enough to cause stones often remain unknown. Some conditions that reduce citrate levels in the urine are:

- Renal tubular acidosis
- Potassium or magnesium deficiency
- Kidney failure
- Chronic diarrhea

In addition to citrate, there are other substances found in the urine that prevent calcium from forming stones. Some of these substances include nephrocalcin-A and uropontin, glycosaminoglycan, magnesium, and pyrophosphate.

STRUVITE STONES

Struvite stones form when the urinary tract is infected with certain bacteria that secrete specific enzymes. These bacteria, called urea-splitting bacteria, have the ability to precipitate a chemical reaction that results in the formation of struvite stones. The stone-promoting bacteria are usually *Proteus*, but may also include *Pseudomonas*, *Klebsiella*, *Providencia*, *Serratia*, and *Staphylococcus*.⁴⁻⁷ Women are twice as likely to have struvite stones than are men.⁷ Because struvite stones are almost always caused by urinary tract infections, they are often called "infection stones."

URIC ACID STONES

Uric acid stones most often form as a result of high concentrations of uric acid crystals, a condition known as hyperuricuria. These stones are associated with urine pH less than 5.5; high purine intake (eg, organ meats, legumes, fish, meat extracts, gravies); or malignancy.

Approximately 25% of patients who have a kidney stone composed of uric acid also have gout.⁹ The following conditions contribute to hyperuricuria:⁷

- Genetic factors
- Diets overly rich in animal proteins
- Gout
- Certain medications, such as some chemotherapy agents, diuretics, and salicylates
- Binge drinking
- Lead toxicity
- Certain blood diseases (eg, leukemia, multiple myeloma, and lymphomas)
- Chronic diarrhea

CYSTINE STONES

Cystine stones are found in patients with an inherited disorder that causes abnormal transport of the amino acids cystine, ornithine, lysine, and arginine in the kidney and gastrointestinal tract.

PRESENTATION AND DIFFERENTIAL DIAGNOSIS

It is estimated that 80 to 85% of urinary calculi will pass spontaneously.⁹ There are several factors that influence the ability to pass a stone, including the person's size, prior stone passage, prostate enlargement, pregnancy, and the stone's size. A 4-mm stone has an 80% chance of passage, whereas a 5-mm stone has a 20% possibility of passage.¹⁰

In some situations, the presence of renal stones will be accompanied by considerable discomfort. Urolithiasis should always be considered in the differential diagnosis of abdominal pain.⁶ The classic patient with renal colic is in excruciating unilateral flank or lower abdominal pain, pacing about and unable to lie still. The pain is not related to any precipitating event (such as trauma) and is not relieved by postural changes. This presentation is in contrast to a patient with peritoneal irritation who will typically remain as motionless as possible to minimize discomfort. Some patients with urolithiasis complain of nausea and vomiting that is due to stimulation of the celiac plexus. Fever is not part of the presentation of uncomplicated nephrolithiasis. If fever is present, hydronephrosis with infection, pyonephrosis, or perinephric abscess should be suspected.⁹

The pain of renal colic often begins as vague flank pain. Patients will often ignore this early symptom until the pain advances into waves of severe pain. It is generally believed that the pain of renal colic is due to the dilation and spasm of the ureter from transient obstruction as

the stone moves through the urinary tract. The symptoms the patient experiences will vary depending on the stone's location (Table 2). Typically, the pain tends to migrate caudally and medially as the stone works its way down the ureter.

TABLE 2. Relationship of Stone Location to Symptom Presentation⁶

Stone Location	Common Symptoms
Kidney	Vague flank pain, hematuria
Proximal ureter	Renal colic, flank pain, upper abdominal pain
Middle section of ureter	Renal colic, anterior abdominal pain, flank pain
Distal ureter	Renal colic, dysuria, urinary frequency, anterior abdominal pain, flank pain

It should be noted that the size of the stone does not necessarily predict the severity of the pain; a very tiny crystal with sharp edges can cause intense pain, whereas a larger round stone may not be as problematic.⁷ If the stone is too large to pass easily, pain continues as the muscles in the wall of the tiny ureter try to squeeze the stone along into the bladder. As a stone grows or moves, blood may appear in the urine. As the stone moves down the ureter closer to the bladder, the patient may complain of urinary frequency or a burning sensation during urination.

Many other conditions can cause symptoms similar to those of renal colic. In women, gynecologic conditions such as ovarian torsion, ovarian cyst, and ectopic pregnancy must be considered. In men, symptoms of testicular tumor, epididymitis, or prostatitis, may mimic the symptoms of distal ureteral stones.⁶ Other general causes of abdominal pain such as appendicitis, cholecystitis, diverticulitis, colitis, constipation, or hernia may exhibit similar discomfort. In patients older than 60 years with no prior history of stones, abdominal aortic aneurysm must be ruled out before the diagnosis of nephrolithiasis is pursued.^{6,9} Finally, other urologic conditions, such as renal or ureteral tumors, must also be excluded.

DIAGNOSIS

An organized diagnostic approach in the confirmation of urinary calculi is recommended because of the various presentations of renal colic and its broad differential diagnosis (Figure 1).⁷

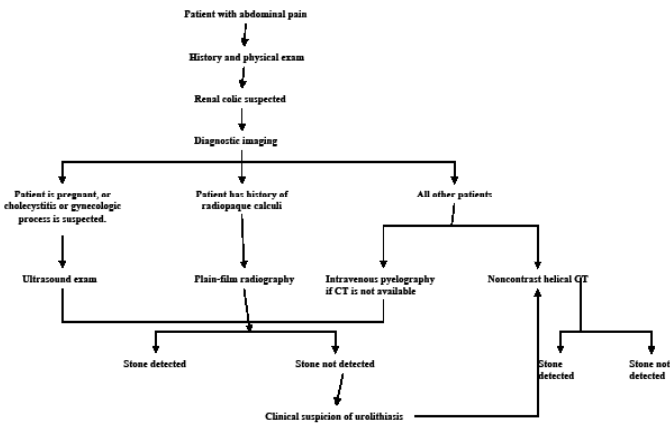


FIGURE 1. Diagnostic approach to suspected renal colic. (Adapted from *American Family Physician*, Vol. 63, No. 7).

MEDICAL HISTORY

The diagnosis of urinary tract calculi should begin with a detailed medical history. Important information includes whether there is a family history of calculi, the duration of symptoms, and the pattern of pain over time. Additionally, signs and symptoms of sepsis are recorded. The physical examination, rather than confirming the diagnosis of urinary calculi, is often more valuable for ruling out nonurologic disease.

Once the diagnosis of urinary calculi is made, other information from the patient's medical history can help determine the underlying cause of the stone(s). For example, the patient's age is a significant factor. Kidney stones that occur in children and young patients are more likely to be a result of an inherited problem that can cause cystine, xanthine, or in some cases, calcium oxalate stones.⁷ Knowing the patient's history of cancer, sarcoidosis, or small bowel disease as well as any medications being taken—including non-prescription substances, particularly high doses of vitamins D or C and calcium-containing antacids—may help predict which type of crystal has formed the stone.

URINALYSIS

All patients suspected of having urinary calculi should have a urinalysis performed. Aside from the typical microhematuria, other important findings are the urine pH and the presence of crystals, which may also help identify the stone composition. Patients with uric acid stone usually present with acidic urine, whereas those with stone formation resulting from infection have an alkaline urine.⁶ A urine culture should be routinely performed because identifying the presence of bacteria can affect the choice of therapy. A small amount of pus in the urine (pyuria) is often a response to irritation caused by

a stone. If pyuria is not accompanied by the presence of bacteria, it is not generally thought to signify a coexistent urinary tract infection.

DIAGNOSTIC IMAGING

Although renal colic may be suspected based on the patient's medical history and physical examination findings, diagnostic imaging is essential to confirm the size and location of urinary tract calculi. Several imaging modalities can be employed; each has advantages and limitations (Table 3).

ULTRASONOGRAPHY

Ultrasonography has a limited role in the diagnosis and management of urinary tract stones. Although ultrasonography is readily available, quickly performed, and can identify stones located in the kidney, it cannot readily distinguish ureteral stones (sensitivity = 19%). This is a significant drawback because ureteral stones are far more likely to be symptomatic than renal calculi.¹² However, if a stone is visualized by ultrasound, the finding is reliable (specificity = 97%).

Although ultrasound will readily identify hydronephrosis, which may be a manifestation of ureteral obstruction, it is frequently limited in defining the level or nature of obstruction. Ultrasound examinations do not typically provide enough specific information, such as precise intrarenal location, to be used for treatment decisions; therefore, many urologists request other imaging techniques before treatment to confirm location and define the pelvicaliceal anatomy.

PLAIN FILM RADIOGRAPHY

Plain film radiography of the kidneys, ureters, and bladder (KUB) may be adequate for discerning the size and location of urinary tract stones, because the majority are calcium-containing. Less radiopaque calculi, such as pure uric acid, struvite, or cystine stones will be difficult, if not impossible, to detect on plain film radiographs. Unfortunately, even radiopaque calculi are often obscured by stool or bowel gas. In addition, stones may be disguised if they lie over the bony pelvis or transverse processes. Furthermore, other conditions, such as gallstones and phleboliths (ie, calcified pelvic veins), may be misinterpreted as stones.

KUB is most effective in managing patients who have known radiopaque stones. This is especially true in planning fluoroscopically guided, extracorporeal shock wave lithotripsy (ESWL) or monitoring the progress of stone fragments after ESWL.

TABLE 3. Imaging Modalities Employed in the Diagnosis of Ureteral Calculi^{6,11}

Modality	Sensitivity (%)	Specificity (%)	Advantages	Limitations
Ultrasonography	19	97	Accessible Inexpensive Safe Radiolucent stones in the kidney visible	Limited accuracy for renal stones Ureteral stones not seen Poor anatomic information Reproducibility of size measurement limited Fragmentation not readily appreciated
Plain film radiography	45 to 59	71 to 77	Accessible Inexpensive Good reproducibility for size measurement Fragmentation readily assessed Good for followup of ureteral calculi	Radiation Bowel gas may limit visibility No information about caliceal anatomy Radiolucent stones not seen
Intravenous urography (IVU)	64 to 87	92 to 94	Accessible Excellent anatomic definition	Radiation Requires bowel preparation and use of contrast media Poor visualization of nongenitourinary conditions Delayed images required in high-grade obstruction Radiolucent stones may not be seen
Non-Contrast Helical CT	95 to 100	94 to 96	Very high diagnostic accuracy All stones visible (except indinavir) Caliceal anatomy may be reconstructed Provides indirect signs of the degree of obstruction Provides information on congenitourinary conditions Ability to measure stone density	Radiation dose higher than that of IVU Limited availability Relatively expensive

INTRAVENOUS UROGRAPHY (IVU)

For many years IVU has been the standard imaging modality for urinary tract calculi. IVU can provide useful information regarding stone size, location, radiodensity, pelvicaliceal anatomy, and degree of obstruction present. IVU is widely available and can easily differentiate ureteral calculi from nonurologic radiopacities. The ability of IVU to clearly visualize the contours of the caliceal anatomy is its most important contribution to the management of renal stones.¹¹

IVU accuracy can be increased with proper bowel preparation, although this requires time and often cannot be achieved when a patient is being seen in the emergency department. Compared to ultrasonography and KUB radiography, IVU has greater sensitivity and specificity. However, some non-obstructing radiolucent stones may not be clearly identified.

IVU necessarily uses iodinated contrast media, which is associated with a small risk of adverse effects (ie, nephrotoxic effects, metabolic acidosis in patients taking metformin). This modality may be contraindicated in some individuals, such as those persons with known iodine allergy or impaired renal function. Proper patient screening, including the measurement of serum creatinine levels, can reduce the risk of adverse effects resulting from the contrast agent.

The radiation dose from a standard IVU series is modest and estimated to be at 1.6 mGy.¹³

NON-CONTRAST HELICAL CT

NCHCT was first described in 1995 by Smith et al.¹⁴ Since that time, NCHCT has gained widespread acceptance among radiologists, urologists, and emergency medicine physicians and has become the standard technique for evaluation of suspected renal colic.¹⁵ The advantage of NCHCT compared to all other techniques is its diagnostic accuracy. More than 99% of stones—including those that are radiolucent on plain film radiography—will be seen on NCHCT.¹⁶ The exceptions are the rarely occurring pure matrix and indinavir stones.¹¹

In addition, NCHCT can be rapidly performed and interpreted and does not require the administration of intravenous contrast material. NCHCT also provides most of the information required for the management of ureteral calculi, although KUB is frequently used for follow-up purposes. In addition to demonstrating the size and site of the stone, measurement of stone density can also be useful. Stones of greater than 1000 HU appear to respond less well to ESWL.¹⁷ Through a number of secondary CT signs, the presence of associated urinary tract obstruction can also be inferred from NCHCT.¹¹

The greatest drawbacks to the use of NCHCT are that it is not yet universally available and that it delivers a relatively high radiation dose, particularly to the gonads. In a recently published article by Heneghan and coworkers,

dose estimates to the uterus and ovaries were 18 mGy with a single-detector row scanner and 23 mGy with a multi-detector row scanner.¹⁵ This level of radiation exposure is of particular concern because many patients who have stone disease are young and have a tendency to experience repeat stone formation. Therefore, these patients have the potential of undergoing CT of the abdomen and pelvis many times during the course of their lives.

Because of the aforementioned concerns, researchers have looked at ways to reduce the radiation dose while maintaining the diagnostic accuracy that sets NCHCT apart.^{15,18} The Heneghan study concluded, "In patients who weighed less than 200 lb (90 kg), unenhanced helical CT performed at a reduced tube current of 100 mA demonstrated a high accuracy when compared with the accuracy of the standard technique. This CT technique results in a concomitant decrease in radiation dose of 25% from multi-detector row CT and 42% for single-detector row CT. This technique has been incorporated into our routine protocol for detection of stones and, in our opinion, promises particular benefit to young patients who experience repeat stone formation."¹⁵

CONCLUSION

Urinary tract calculi are a common medical problem, occurring in approximately 10% of the population at some point in their lives. Stones can be composed of a variety of materials, although the most common consist of calcium salts. Many different causes of stone formation have been identified, although in many specific cases no clear cause of urinary tract calculi can be identified.

Although there is a classic presentation of urinary tract calculi, many other conditions can cause symptoms similar to kidney stones. Diagnosis requires a detailed medical history, physical examination, and urinalysis. In addition, diagnostic imaging is essential to uncover information about the urinary tract calculi.

The goal of modern imaging is to provide accurate information concerning the presence, size, and precise location of a renal or ureteral stone, in addition to delineating the intracaliceal anatomy. Due to its many advantages, NCHCT is currently the imaging method of choice in the identification and evaluation of urinary tract calculi, although it is not always available, and concerns about radiation dose exist.

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URINARY TRACT CALCULI POST TEST

Expires: May 15, 2011 Approved for 1 ARRT Category A Credit.

1. **Ureterolithiasis refers to stones located in the**
 - a. bladder.
 - b. renal pelvis.
 - c. calyces.
 - d. ureter.
2. **What is the condition wherein a stone causes obstruction that results in dilatation, distention, and enlargement of the kidney's collecting system?**
 - a. Nephrolithiasis
 - b. Renal colic
 - c. Hydronephrosis
 - d. Hydrouria
3. **The National Institutes of Health estimate that ____% of people in the United States will have a kidney stone at some point in their lives.**
 - a. 2
 - b. 6
 - c. 10
 - d. 50
4. **Kidney stones are most common in**
 - a. middle-aged, white men.
 - b. black children.
 - c. elderly, Asian women
 - d. young, white women.
5. **What type of stones are the most common?**
 - a. Calcium stones
 - b. Struvite stones
 - c. Uric acid stones
 - d. Indinavir stones
6. **All of the following are associated with the formation of stones composed of calcium salts attributed to hypercalciuria EXCEPT**
 - a. increased gut absorption of calcium.
 - b. excessive levels of chloride.
 - c. renal calcium leak.
 - d. excessive consumption of calcium-containing dairy products.
7. **Approximately 25% of patients who have a kidney stone composed of uric acid also have**
 - a. metastatic disease.
 - b. gout.
 - c. kidney failure.
 - d. staphylococci.
8. **What percentage of urinary calculi will pass spontaneously?**
 - a. 5% to 10%
 - b. 20% to 30%
 - c. 40% to 55%
 - d. 80% to 85%
9. **The classic presentation of a patient with renal colic includes all of the following EXCEPT**
 - a. excruciating flank or lower abdominal pain.
 - b. nausea.
 - c. vomiting.
 - d. abdominal pain that abates when the patient is recumbent.
10. **Renal colic, dysuria, urinary frequency, anterior abdominal pain, and flank pain are symptoms indicative of a stone located in the**
 - a. distal ureter.
 - b. middle section of the ureter.
 - c. proximal ureter.
 - d. kidney.
11. **In patients older than 60 years with no prior history of stones, _____ must be ruled out before the diagnosis of nephrolithiasis is pursued.**
 - a. diverticulitis
 - b. abdominal aortic aneurysm
 - c. renal malignancy
 - d. diabetes mellitus
12. **In the diagnosis of urinary tract calculi, what information should be included in the medical history?**
 - a. Family history of calculi
 - b. Duration of symptoms
 - c. Pattern of pain over time
 - d. Signs and symptoms of sepsis
 - a. 1 and 2
 - b. 2 and 3
 - c. 1 and 4
 - d. 1, 2, 3, and 4
13. **Urinary tract infection should be considered when urinalysis reveals pyuria and**
 - a. microhematuria.
 - b. bacteria.
 - c. acidic pH.
 - d. crystals.
14. **Diagnostic imaging is essential to**
 - a. confirm the size and location of urinary tract calculi.
 - b. identify the exact stone composition.
 - c. determine the likelihood of recurrence of urinary tract calculi.
 - d. determine the underlying cause of the stone.
15. **Which of the following statements is TRUE concerning the use of ultrasound in the diagnosis and management of urinary tract stones?**
 - a. Ultrasonography is much better at visualizing ureteral stones than it is at visualizing renal stones.
 - b. A major drawback of ultrasonography is that it cannot identify hydronephrosis.
 - c. Ultrasonography is frequently limited in defining the level or nature of ureteral obstruction.
 - d. The sensitivity and specificity of ultrasonography is comparable to that of non-contrast helical computed tomography.

- 16. Visualization of the kidneys, ureters, and bladder may be adequate for discerning**
- calcium-containing stones.
 - pure uric acid stones.
 - struvite stones.
 - cystine stones.
- 17. The most important contribution of intravenous urography (IVU) to the management of renal stones is**
- accuracy in detecting nonobstructing radiolucent stones.
 - ability to clearly visualize the contours of the caliceal anatomy.
 - use in the emergency room setting.
 - a higher sensitivity and specificity compared to all other imaging modalities.
- 18. The radiation dose from a standard IVU series is estimated to be at**
- .05 mGy
 - 1.6 mGy
 - 5.2 mGy
 - 18 mGy
- 19. What percentage of urinary tract calculi will be seen on non-contrast helical computed tomography?**
- 40
 - 60
 - 85
 - 99
- 20. Stones on a computed tomographic image that measure greater than 1000 HU**
- are probably indinavir stones.
 - will probably pass spontaneously.
 - do not respond as well to extracorporeal shock wave lithotripsy.
 - are less likely to cause ureteral obstruction.



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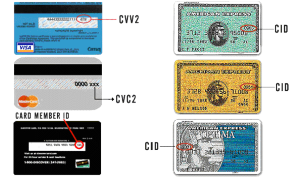
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