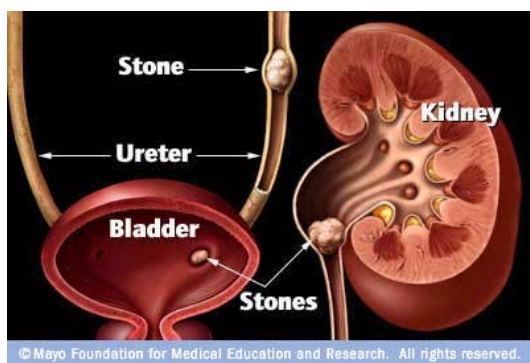
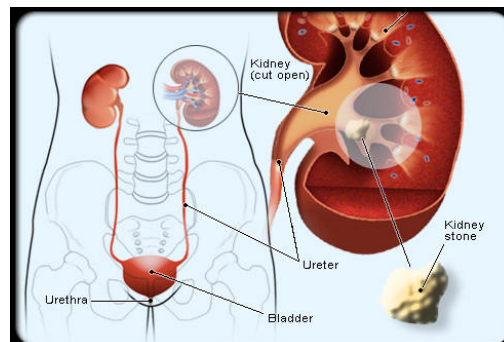


## RENAL (KIDNEY) STONES

### Renal Anatomy

The kidneys are bean-shaped organs, each about the size of a fist. They are located near the middle of the back, just below the rib cage, one on each side of the spine. The kidneys filter waste products and extra water from the bloodstream. The wastes and excess water become urine, which flows to your bladder through tubes called ureters. Your bladder stores urine which is eventually expelled through the urethra.



### Risk Factors

According to the U.S. National Institutes of Health (NIH), roughly one person in ten develops kidney stones during their lifetime. The kidneys must maintain an adequate amount of water in the urine to dissolve the removed waste products. High levels of substances that do not dissolve completely (e.g., calcium, oxalate, uric acid) may form crystals that slowly build up into kidney stones. Stones can be as small as a grain of sand to as large as a golf ball.

Urine normally contains chemicals—citrate, magnesium, pyrophosphate—that help prevent the formation of crystals and stones. Low levels of these inhibitors or concentrated urine caused by decreased fluid intake can contribute to the formation of kidney stones. It is common, however, for kidney stones to have no definite, single cause. Research is ongoing to better identify the cause of stone formation, but our knowledge at this point is still lacking. Nevertheless, the following factors described below, often in combination, create the conditions in which kidney stones may develop.

- Lack of fluids. If you don't drink enough fluids, especially water, your urine is likely to have higher concentrations of substances that can form stones. That's also why kidney stones are more common in hot, dry climates or in people who exercise strenuously without replacing lost fluids.
- Family or personal history. If someone in your family has kidney stones, you're more likely to develop stones too. And if you've already had one or more kidney stones, you're at increased risk of developing another.
- Age and sex. Most people who develop kidney stones are between 20 and 70 years of age. Men are more likely to develop kidney stones than are women.
- Diet. A high-protein, high-sodium and low-calcium diet may increase your risk of some types of kidney stones.
- Limited activity. You're more prone to develop kidney stones if you're bedridden or very sedentary for a long period of time. This is partly because limited activity can cause your bones to release more calcium.
- Obesity. High body mass index (BMI), increased waist size and weight gain have been linked to kidney stones in long-term studies of large populations. The relationship is strongest in women.
- High blood pressure. Having high blood pressure doubles your risk of forming kidney stones.
- Gastric bypass surgery, inflammatory bowel disease or chronic diarrhea. Changes in the digestive process affect your absorption of calcium and increase the levels of stone-forming substances in your urine.

### Symptoms

Stones that reside in the kidney generally do not cause discomfort. The pain associated with kidney stones occurs when the stone moves into the ureter — the tube draining the kidney and connecting to the bladder — resulting in obstruction of urine flow. This obstruction can lead to the following:

- Pain in the side and back, below the ribs – this pain is usually only on the side of the stone and does not cross over to the other side
- Fluctuations in pain intensity, with periods of pain lasting 20 to 60 minutes
- Pain waves radiating from the side and back to the lower abdomen and groin
- Bloody, cloudy or foul-smelling urine
- Pain on urination
- Nausea and vomiting
- Persistent urge to urinate
- Fever and chills if an infection is present

Kidney stones that don't cause these symptoms may show up on X-rays when you seek medical care for other problems, such as blood in the urine or recurring urinary tract infections.

### Types of Stones

- Calcium stones. Roughly four out of five kidney stones are calcium stones, usually in the form of calcium oxalate. Oxalate is found in some fruits and vegetables, but the liver produces most of the body's oxalate supply. Dietary factors, high doses of vitamin D, intestinal bypass surgery and several different metabolic disorders can increase the concentration of calcium or oxalate in urine.
- Struvite stones. Found more often in women, struvite stones are almost always the result of urinary tract infections. Struvite stones may be large enough to fill most of a kidney's urine-collecting space, forming a characteristic stag-horn shape.
- Uric acid stones. Approximately 10% of patients with kidney stone disease develop this type of stone. These are formed from a byproduct of protein metabolism. A high-protein diet increases the likelihood for developing uric acid stones. Gout also leads to uric acid stones. Certain genetic factors and disorders of the blood-producing tissues also may increase the risk.
- Cystine stones. These stones represent only a small percentage of kidney stones. They form in people with a hereditary disorder that causes the kidneys to excrete excessive amounts of certain amino acids (cystinuria).

### Diagnosis

Diagnosis of renal stone disease involves a medical history, physical examination, laboratory evaluation and imaging tests. Physical examination may be difficult if the patient is experiencing severe pain and is unable to remain still. Lightly tapping on the kidney region often worsens the pain. Fever may indicate a urinary tract infection that requires antibiotics and in some cases urgent intervention.

If the diagnosis is suspected based upon presentation with typical symptoms, then imaging tests are usually obtained to confirm the diagnosis. A helical CT scan without contrast material is the most common test to detect stones or obstruction within the urinary tract. All stones except for stones that form as a result of HIV anti-viral medications, are visible on a CT scan. An intravenous pyelogram (IVP; an x-ray of the abdomen along with the administration of contrast dye into the bloodstream) was the test most commonly used to detect urinary tract stones, but this test has a greater risk of complications, takes longer, and involves higher radiation exposure than a non-contrast helical CT scan. Helical CT scans have been shown to be a significantly more effective diagnostic tool than the IVP in the diagnosis of urinary tract stones although IVP is utilized as a confirmatory study at times. A plain abdominal x-ray may also be ordered depending upon the choice of treatment.

In pregnant women or those who should avoid radiation exposure, an ultrasound examination may be

done to help establish the diagnosis, although this is not the most conclusive modality to evaluate renal and ureteral stones.

### Treatment

With ample fluid intake (8-10 glasses/day), most kidney stones pass on their own within 48 hours. Several factors influence the ability to pass a stone, including the size of the person, prior stone passage, pregnancy, stone size and stone location in the urinary tract. A 4 mm stone has an approximate 80% chance of passage while a 5 mm stone has a 20-30% chance. Stones larger than 9-10 mm rarely pass without treatment.

Stones that cannot be treated with conservative measures — because they're too large to pass on their own or because they cause bleeding, kidney damage, ongoing urinary tract infections, or intractable pain and nausea — may need treatment. If stones are incidentally found in the kidney, then treatment may be chosen to resolve or treat the stone before it can lead to symptoms associated with stone passage or obstruction. Treatment options include:

- Medical management. Drink fluids, take prescribed pain and nausea medication and strain urine to catch a stone if it passes. Medications known as alpha-blockers have been shown to increase stone passage rates and are often prescribed as well. Uric acid stones are visible on CT scan but not seen on plain x-rays. These stones can be dissolved by medications that make the urine less acidic. Unfortunately, most stones are calcium-based and either need to pass spontaneously or be treated surgically, as they will not dissolve with medication alone.
- Cystoscopy and ureteral stent placement. A lighted camera is passed through the urethra into the bladder and a small plastic tube is placed in the ureter, extending from the bladder to the kidney. This relieves the obstruction caused by the stone. This procedure can be performed emergently to relieve acute pain and nausea and is utilized to allow infection to drain from an obstructed and infected kidney. A ureteral stent may also be placed in conjunction with the following procedures when indicated.
- Extracorporeal shock wave lithotripsy (ESWL). This procedure uses shock waves to break the stones into tiny pieces that are then passed in the urine. The shock waves are centered on the stone utilizing an imaging modality called fluoroscopy. Stones have to be visible on plain x-rays in order to be seen on fluoroscopy. A light anesthesia secondary to some moderate pain caused by the shock waves is usually necessary. Complications that may occur with ESWL include blood in the urine, bruising on the back or abdomen, bleeding around the kidney and other adjacent organs, and discomfort as the stone fragments pass through the urinary tract. In addition, if the stone doesn't shatter completely, you may need a second round of ESWL or ureteroscopic stone removal.
- Ureteroscopic stone removal. This procedure may be used to remove a stone lodged in a ureter. The stone is grasped with a small instrument (ureteroscope) that is passed through the urethra into the bladder and up into the ureter. Ultrasound or laser energy also can be directed through the scope to shatter the stone. These methods work especially well on stones in the lower part of the ureter. While the clearance rates are higher with ureteroscopic stone removal, the risks increase with more aggressive intervention. Fortunately, complications are rare and include inability to treat stone and injury to the ureter. Following this approach, ureteral stents are often placed for a few days and removed in the office.
- Percutaneous nephrolithotomy. When ESWL isn't effective, or the stone is very large, your surgeon may remove your kidney stone through a small incision in your back using an instrument called a nephroscope. This surgical procedure is performed under general anesthesia. A needle and guidewire are used to access the inside of the kidney. The surgeon then manipulates surgical instruments through the catheters and over guidewires so as to fragment and remove the kidney stones. This procedure achieves a better stone-free outcome in the treatment of medium and large stones than shock wave lithotripsy. Often, patients stay in the hospital for several days and may have a small tube called a nephrostomy tube left in the kidney during the healing process. Most patients resume normal activity within 2 weeks.

### Kidney Stone Prevention

A person who has had more than one kidney stone may be likely to form another; so, if possible, prevention is important. The doctor will ask about medical and family history, occupation and dietary habits. If a stone is captured, then a stone analysis by the laboratory may help in treatment planning. Laboratory tests evaluating the urine and blood are ordered. A 24-hour urine collection is used to measure urine volume and levels of acidity, calcium, sodium, uric acid, oxalate, citrate, and creatinine—a product of muscle metabolism. This information is used to try to determine the abnormalities leading to stone formation. Unfortunately, our understanding of the causes of stone formation is lacking despite active research, and as such, the cause is not always identifiable. In any case, the following recommendations have been shown to decrease future stone formation:

#### Dietary changes

- Drink, drink and drink some more. Stone formers need to drink 9-12 glasses (about 3 liters) of fluids every day — and even more if you live in a hot, dry climate. Water is best. Include a few glasses of citric acid fruit juices (lemonade, orange juice) every day, too. Avoid powdered lemonade mixes. These juices increase the levels of citrate in your urine, and citrate helps prevent stone formation.
- If you tend to form calcium oxalate stones, your doctor may recommend restricting foods rich in oxalates. These include rhubarb, star fruit, beets, beet greens, collards, okra, refried beans, spinach, Swiss chard, sweet potatoes, sesame seeds, almonds and soy products.
- Studies show that an overall diet low in salt and very low in animal protein can greatly reduce your chance of developing kidney stones.
- As a general rule, restricting calcium intake does not lower your risk. In fact, researchers have found that women with a high dietary calcium intake are less likely to develop kidney stones than are women who consume less calcium. Calcium supplements seem to have the same protective effect as dietary calcium, but only if they're taken with meals.

#### Lifestyle modification.

- Avoid inactivity and obesity.

#### Medications.

- Medications can control the acidity and calcium levels in urine and may be helpful in people who form certain kinds of stones. The type of medication prescribed will depend on the kind of kidney stones you have:
  - Calcium stones. To help prevent calcium stones from forming, your doctor may prescribe a thiazide diuretic, a medication that removes calcium from the urine, or a phosphate-containing preparation that decreases dietary calcium absorption. If you have calcium stones because of a condition known as renal tubular acidosis (RTA), you may be prescribed sodium bicarbonate or potassium bicarbonate.
  - Uric acid stones. Your doctor may prescribe allopurinol to reduce uric acid levels in your blood and urine and a medicine to keep your urine alkaline. In some cases, allopurinol and an alkalinizing agent may dissolve the uric acid stones.
  - Struvite stones. To prevent struvite stones, the first goal is to keep urine free of bacteria that cause infection. Long-term use of antibiotics in small doses may be useful to achieve this goal.
  - Cystine stones. Cystine stones are the hardest stones and the most difficult to treat. Your doctor may prescribe certain medications to alkalinize the urine or to bind the cystine in the urine in addition to recommending an extremely high urine output.