

# What is a kidney stone and what happens if I get one?

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## What is a kidney stone?

A kidney stone is a buildup of solid material that clumps together within the urine and forms within the kidney. Kidney stones are usually hard because they are made up mainly of crystals. Almost all (98%) of the kidney stone weight is made up of crystals. But kidney stones also have soft mushy parts called matrix. The soft part is usually only 2% of the kidney stone weight. This soft matrix material can be made of proteins, sugars, water or a combination of them.

When kidney stones are soft, it means that there is more of the matrix material in the stone than usual. Sometimes more than half of the weight of the kidney stone can be from the soft matrix material. When this happens, the stone will be soft and mushy. The most common type of soft and mushy kidney stone is an infection kidney stone. Rarely kidney stones can be mushy because they contain protein material.

## Different kinds of kidney stones

### Calcium stones

Most kidney stones contain calcium. Actually, about eight out of 10 kidney stones contain calcium. There are different kinds of calcium kidney stones, but calcium oxalate and calcium phosphate are the most common kinds. Of these two, calcium oxalate is the most common.

Like most stones, there are many different reasons why a calcium stone grows. Many chemicals can help cause growth of a calcium stone. But there is another reason for growth of calcium stones that is probably more important than the chemicals in the urine. This other reason is that you're not drinking enough water and other fluids each day. If you don't have enough to drink everyday then the kidneys make less urine and the urine becomes more concentrated (it will look darker in colour) with chemicals which can help start to form calcium crystals in the urine. These calcium crystals can grow into stones if enough days go by where you're not drinking enough fluid.

The chemicals in the urine that help grow calcium stones are calcium, oxalate and uric acid. There is also a compound that is naturally found in our bodies and urine that stops calcium stones from growing and it is called citrate. You may recognize this word, as it is related to citrus. Yes, lemons, lemonade and other citrus fruits like oranges, might prevent stones.

## Infection kidney stones

About one in 10 kidney stones are infection kidney stones. Infection stones are also called struvite stones, and contain ammonium, magnesium and phosphate. Infection stones grow when there is an infection in the urine and that causes the stone to become infected.

The bacteria also cause the acid level in the urine to decrease. This is important because an infection stone will only grow when the acid level in the urine is low. Not all bacteria can cause infection stones. You need a special kind of bacteria to make infection stones. The bacteria are special because they produce a chemical that causes the infection kidney stone. The chemical is called urease.

So, for an infection stone to grow you must have special bacteria that produce a chemical called urease; this chemical reaction causes the acid level in the urine to decrease enough to allow an infection stone to grow.

## Uric acid kidney stones

About one in 10 kidney stones are uric acid kidney stones. Uric acid kidney stones are special because they are the only kind of kidney stone that can be broken up or dissolved by taking a pill. There are three main reasons why you make uric acid crystals and stones in your kidneys:

- (1) There is too much acid in your urine; when there is too much acid you grow uric acid stones.
- (2) You are not drinking enough water and other fluids each day. When you don't drink enough the kidneys make less urine and the urine becomes more concentrated with chemicals which can start to form crystals in the urine and these crystals can grow into stones.
- (3) You have too much uric acid chemical in your urine.

## Cystine kidney stones

Cystine kidney stones are very rare. About one out of 100 kidney stones will be a cystine stone in adults. In children, up to one out of 10 kidney stones can be made of cystine. Cystine stones are very hard stones. Many doctors call them the hardest kidney stones a human can make. This makes them more difficult to break and completely remove.

Cystine stones grow in the urine when there is too much cystine in the urine (or cystinuria). Besides high levels of cystine in the urine, there are other chemicals in the urine that can help create cystine stones. For example, if there are too many calcium chemicals in the urine, or if there is too much uric acid in the urine, or if there is not enough citrate in the urine, then a cystine stone could grow in the urine.

## Kidney stones caused by medications

Sometimes, the medication you take form kidney stones. This means that the kidney stone is made up of the medication that you took. See Table 1 for the most common medications that cause these kinds of stones.

Also, sometimes medications can cause calcium kidney stones. Examples of medications that can cause calcium kidney stones include furosemide and acetazolamide.

**Table 1. Medications that form kidney stones**

| Generic name  | Trade name |
|---------------|------------|
| Triamterene   | Dyrenium   |
| Adenosine     | Adenocard  |
| Silica        | Ludox-Ls   |
| Indinavir     | Crixivan   |
| Guaifenesin   | Robatussin |
| Ephedrine     | Ephedra    |
| Ciprofloxacin | Cipro      |

## Other rare types of kidney stones

There are a few other kinds of kidney stones, but remember that these stones are not very common. Most doctors in North America will never see patients with these kinds of stones. These stones are called xanthine, dihydroxyadenine and ammonium acid urate stones.

Kidney stones can be made up of more than one of the different types. When a kidney stone is made up of two or more different types, we call it a “mixed” stone. One of the most common types of a mixed stone contains calcium and uric acid. Mixed stones form in the same way as the two parts would on their own.

## Reasons kidney stones grow

We don't know all the reasons why people get kidney stones. The making of a kidney stone is a hard thing to understand. There are many possible ways that a kidney stone can form in the urine. One thing we do know is that there needs to be something called supersaturation of the urine. This means that there is a higher than normal concentration of chemicals in the urine which causes kidney stones. See Table 2 for a list of the things we know about how kidney stones are formed.

There are chemicals in the urine that help stones grow and there are other chemicals that stop stones from growing. These chemicals are shown in Table 3.

There are many different kinds of kidney stones and many different ways they can form. We still have lots to learn.

## Table 2. Who gets kidney stones?

- Men get stones more often than women
- Race: Whites (70%), Hispanics (63%), Asians (63%), African-Americans (44%)
- Most common age is 30–60 years
- Appears to occur more commonly during summer months
- Appears to occur more commonly in hot climates
- People who have heat exposure and dehydration at work (cooks, engineering room workers)
- People who sit down all day at their office job
- People who are obese
- People who don't drink a lot of water or other fluids

## Table 3. Chemicals that stop stones from growing

|               |                                  |                            |
|---------------|----------------------------------|----------------------------|
| Inhibitors    | Glycosaminoglycans (ie. heparin) | Tamm-Horsfall glycoprotein |
| Citrate       | Acid mucopolysaccharides         | Osteopontin                |
| Mg            | RNA                              | Bikunin                    |
| Pyrophosphate | Nephrocalcin                     |                            |

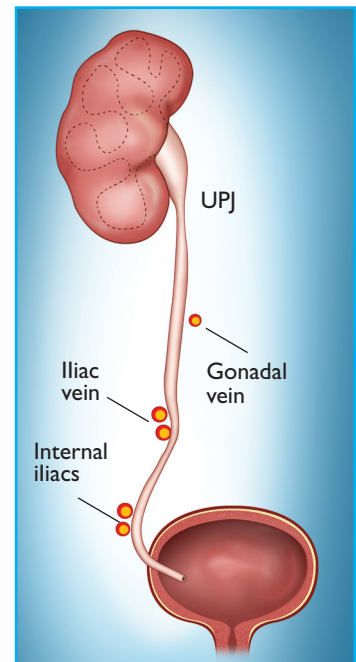
## How can I tell if I have a kidney stone?

Kidney stones are very common. About 15% of us will develop a kidney stone at some point in our lives. Most kidney stones actually do not cause any symptoms, since they simply sit in the kidney and don't cause any blockage.

It is estimated that at any one time, as many as 8% of people have kidney stones and don't know it because they don't have any problems. However, when stones do move around in the kidney or out of the kidney, you will develop symptoms.

The most common symptom is pain. The classic kidney stone attack (or renal colic) happens when a stone moves out of its resting place in the kidney and gets stuck at some point in the tube draining the kidney. This tube is called the ureter.

The most common sites where a stone can get stuck are at the junction of the ureter and the kidney, the point where the ureter tube crosses some large blood vessels in the pelvic area, and the junction where the ureter enters the bladder. Although stones can actually get stuck anywhere along the path of the ureter, these areas are points where there may be narrow spots because of your anatomy (Figure 1).



**Figure 1.** Common sites of anatomical narrowing within the urinary tract.

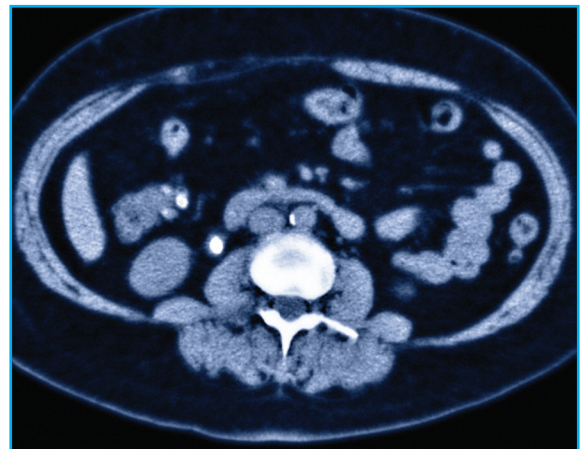
Typically, a kidney stone attack starts abruptly in the flank region of the affected kidney. It can stay in the area of the flank, but can also radiate or move to the front, abdominal and groin regions. The pain is often described as the worst pain you can ever have and is usually rated at 9–10 out of 10. Female patients frequently comment that renal colic pain is worse than the pain they experienced with childbirth.

Another common feature of renal colic pain is that you will have a hard time finding a comfortable position (so it is sometimes called “moving irritation”). If the stone moves down into the lower ureter and gets close to the bladder, it is not uncommon for you to experience irritable symptoms of the bladder with frequent and urgent urination. These symptoms can sometimes be confused with the symptoms of a lower urinary tract infection.

Nausea and vomiting can also occur. The kidney and ureter sit behind the main abdominal cavity; the inflammation and irritation occur because the stone blockage will often upset the gastrointestinal tract enough to cause nausea and vomiting. Finally, the most patients who come to the emergency room with a kidney stone episode will have blood in their urine. Usually, this will only be microscopic blood that is detected by the urine test, but visible blood can also be present.

## How are kidney stones diagnosed?

Even though the above symptoms are quite typical of a kidney stone, diagnostic imaging tests are done to confirm the diagnosis. Your emergency room doctor will need to rule out other possible diagnoses, such as gastrointestinal, abdominal and gynecological diseases, or even a severe infection of the kidney without a stone. The best imaging test to diagnose kidney stones is a computed tomography (CT) scan without intravenous dye (contrast). This test is highly accurate and will correctly diagnose kidney stones in the ureter in about 98% of cases (see Figure 2). A plain abdominal X-ray is often done with the CT scan to see if the stone is visible on plain X-ray. This information is important to know as it may affect the treatment you’ll need; it will also be used to track the stone to see if it is moving or may have passed.



**Figure 2.** Computed tomography image of a right ureteral stone.

In communities or hospitals that don’t have access to a CT scan machine, an ultrasound of the abdomen is another test that can be done. Ultrasound will often show signs of an obstructed kidney or ureter, but it may not be able to see the stone in all cases. If the stone is in the mid to lower ureter, this area of the body can be obscured by bowel and bowel content and this can make it difficult for the ultrasound to “see” this part of the anatomy.

Three other tests can be used: magnetic resonance imaging (MRI), retrograde pyelography and intravenous pyelography (IVP).

The advantage of MRI is that it does not use radiation, but stones do not show up nearly as well compared to CT. So the accuracy rate is much lower compared to CT. Also, at least in Canada, there are fewer MRI machines available, so it usually takes longer to have this done and it's often difficult to have this done in an emergency. One specific situation when the MRI test is used is in the case of a pregnant patient with symptoms of a blocked kidney. In this situation, the MRI is safe for the baby.

Retrograde pyelography is an invasive test performed by a urologist. To do this test, a scope is passed into the bladder (cystoscopy) and then dye (contrast) is injected up one or both ureters using a small catheter. This procedure is usually only done when there is some doubt about the diagnosis or when there is a plan to insert a drainage tube, or stent, into the ureter and kidney.

The IVP exam was common 20 years ago. Now, it's rarely done and usually only in centres that don't have easy access to CT or ultrasound. X-ray dye is injected intravenously; then, five to 10 minutes later a series of abdominal X-rays are done to see if the dye is passing through the kidneys. A normal kidney will process the dye and pass it down the ureter to the bladder. An obstructed kidney will show a delay. Eventually, dye will come through the kidney and stop at the level of obstruction. The accuracy of IVP is inferior to CT and there are allergic risks and possible kidney side effects when giving the intravenous contrast material. Thus, CT is the preferred test of choice for diagnosing kidney stones.

The main disadvantage of CT is that there is more radiation associated with it compared with the other exams. One CT exam without dye has about 10 times the radiation exposure compared to one plain abdominal radiograph. So, emergency doctors are starting to use plain abdominal X-rays and ultrasounds first and only use CT if the diagnosis is still in doubt. Overall, the risks of radiation versus the risks of not making the correct diagnosis have to be weighed for each patient.

## Initial treatment of the patient with an obstructing kidney stone

After an obstructing kidney stone has been diagnosed, the next step is to control your pain. The pain of renal colic is due to a sudden increase in pressure that occurs within the kidney. This increased pressure stretches the kidney and its capsule and this stimulates the pain fibres that send messages to the brain leading to the severe pain. Muscle spasms around the kidney and involving the ureter also contribute to the pain symptoms. This type of pain is so intense that usually narcotics (morphine) are needed. Non-steroidal anti-inflammatory drugs (the same class as aspirin and ibuprofen) are also useful, as these drugs will help to break the muscle spasm described above. Intravenous fluids are also usually administered as nausea and vomiting is quite common and this helps replace fluids and may also aid in the passage of the stone.

In most cases, once the pressure in the kidney and ureter decreases and muscle spasm relaxes, the severe pain diminishes. Continued, unrelenting pain is uncommon. As a result, most patients don't need to be admitted to hospital because of their stone. Although there will usually be some ongoing discomfort, this can be managed with pain medications that can be taken orally. The most common medications prescribed are acetaminophen with codeine (Tylenol #3) and non-steroidal anti-inflammatories (NSAIDs) (ketorolac, diclofenac, indomethacin). When taking these medications, it's important to keep up one's fluid intake to avoid constipation, which can occur with codeine. Also take NSAIDs with food to avoid stomach inflammation and ulcer formation.

Despite the intense pain, you will likely pass your stones spontaneously without needing surgery.

The probability of passing a stone is directly related to the size of the stone. Studies have shown that stones that are less than or equal to 5 mm will pass out on their own between 75–100% of the time within two to four weeks. Stones that are greater than 5 mm have about a 50% chance of passing, and those greater than 7 mm usually only pass 10% of the time. Your treatment plan will depend on the size of the stone.

If your stone is in the 3–4 mm range, you will likely be discharged from the emergency room and asked to follow-up with your family physician. If your stone is 5 mm or more then you may be referred to a urologist for follow-up and treatment if your stone has not passed within the time period. Most patients are also given a prescription for a medication (tamsulosin or Flomax) to relax the ureter muscle so that you can pass the stone.

Less than 10% of patients need admission to hospital. The most important reason to admit someone to hospital and to contact a urologist immediately for advice and help is when you have an obstructing stone and a fever. This is a potentially life-threatening situation. You would need to be started on intravenous antibiotics and have your kidney drained as soon as possible. Without drainage, the toxins associated with the infection can get into the bloodstream and can lead to a condition called septic shock (where the blood pressure drops very low). Drainage of the blocked ureter and kidney allows the infected urine to pass out of the body. Not only is the infection cleared, but this also helps the antibiotics function more effectively.

The most common way to drain an infected, blocked ureter is by taking you to the operating room and performing a scope procedure of the bladder (cystoscopy) and insertion of a temporary tube (stent) into the ureter, alongside the obstructing stone. The stent stays in until the infection has been treated and you can undergo treatment of the stone. The other method of draining the kidney is for you to have a tube placed directly into the kidney under ultrasound guidance. In this case, the tube (nephrostomy tube) is attached to a bag outside the body and urine from that kidney drains into the bag. Similarly, the tube stays in until the infection has cleared and the stone can be treated.

Other less urgent reasons to admit someone to hospital with an obstructing stone include:

- If you have pain that just doesn't go away
- If you have severe nausea and vomiting
- If you have a single kidney that is blocked
- If you have a stone in each ureter blocking both kidneys at the same time (this is rare)

In the latter two situations, ureteral stenting or placing a nephrostomy tube is required within 24–36 hours or temporary kidney failure can occur. Similar to the case where drainage is needed for infection, these drainage tubes remain in place until the stone can be treated and cleared from the urinary tract.

### Key points to remember:

- Kidney stones are painful when they move and block the ureter tube draining the kidney or part of the kidney itself.
- Pain is a direct result of an increase in pressure within the kidney caused by the blocking stone.
- Obstructing stones are diagnosed by imaging the urinary tract with a CT scan, ultrasound, or a plain abdominal X-ray.
- The chance of a stone passing is related to the size of the stone. Those less than 4 mm will pass more than 90% of the time. Stones greater than 7 mm will pass less than 10% of the time.
- Most patients who go to the emergency room with a kidney stone will be able to be discharged and managed with pain pills until the stone passes or needs treatment.
- A stone blocking the kidney associated with a fever is a medical emergency, and you need urgent medical attention.