

● Kidney stones are formed out of hard, crystalline mineral material within the kidney or urinary tract

What I tell my patients about kidney stones

Kidney stone disease (urolithiasis) is a growing problem. Worldwide, around two people in 1,000 develop problems related to kidney stones each year, and up to 20% of people have had problems with kidney stones at some time. In Europe, up to 8% of the population have been affected, but this number is rising. It is estimated that at least 720,000 individuals currently have kidney stone problems in the UK.

It is rare for children to have kidney stones, but there is evidence that this is becoming more commonplace. Stones usually occur in the 30s and 40s, and are more common in men than women. However, this picture is changing: the prevalence in women is on the rise and the age at onset of symptoms is getting younger. Kidney stones are more common in caucasian and Asian populations, while black populations may have a higher risk of infected stones; they are very rare in Israelis, Native Americans, Africans and African-Americans. There are several risk factors (see Box 1) that may affect prevalence.

There is concern that stone disease is on the increase, and if the current problem with obesity grows, then that related to stone disease will as well. The continuing increase in childhood obesity may also be contributing to the growing prevalence of childhood stone disease. There is a growing consensus that having a stone may be a symptom of other underlying problems, such as metabolic syndrome or high blood pressure, and that it should be managed by a multidisciplinary team.

Another concern about stone disease is that there is a high risk of a stone recurring. Up to 15% of

Box 1. Risk factors for kidney stone formation

- Family history
- Urinary tract abnormalities
- Hot climate (living or holidaying)
- Working in hot environments (for example, chefs)
- Dehydration
- Low urine volume
- Sedentary/desk-bound job
- Obesity
- Type 2 diabetes
- Hypertension
- Urinary tract infections
- Tumours or foreign bodies
- Excessive intake of protein and oxalate-containing food
- Chronic laxative abuse
- Excessive intake of antacids
- Regular strenuous exercise
- Psychological stress
- Associated diseases - hyperparathyroidism, renal tubular acidosis, cystinuria, primary hyperoxaluria, jejunio-ileal bypass, Crohn's disease, intestinal resection, malabsorptive conditions, sarcoidosis

first-time stone-formers will have a recurrence within one year, 35% after five years, 50% at ten years and 75% at 20 years. This not only has an impact on the person's health, but also has a cost implication because of the associated healthcare costs and loss of productive working days.

How do stones form?

A kidney stone is a hard, crystalline mineral material formed within the kidney or urinary tract. There are two main theories on how stones form. One is that urine becomes supersaturated with the salt and

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minerals excreted by the kidneys, and that this excess leads to crystals forming. The other is that calcium deposits develop in the filtering systems of the kidneys, forming nuclei onto which calcium oxalate crystals attach themselves to form stones.

Different types of stones

The majority (75–85%) of stones are made of calcium, but 2–15% are struvite, while uric acid stones account for 6–10% and cystine stones 1–2%. The most common type of kidney stone seen in the UK is calcium-containing – usually calcium oxalate or a mixture of calcium oxalate and calcium phosphate. Struvite stones are made of magnesium ammonium phosphate and can grow into large stones such as staghorn calculi (see Figure 1). Acidic urine leads to formation of uric acid stones.

Signs and symptoms

Pain associated with renal stones is one of the main reasons these patients present at A&E departments. Patients usually present with acute kidney and abdominal pain. They may also experience nausea and vomiting and, sometimes, haematuria.

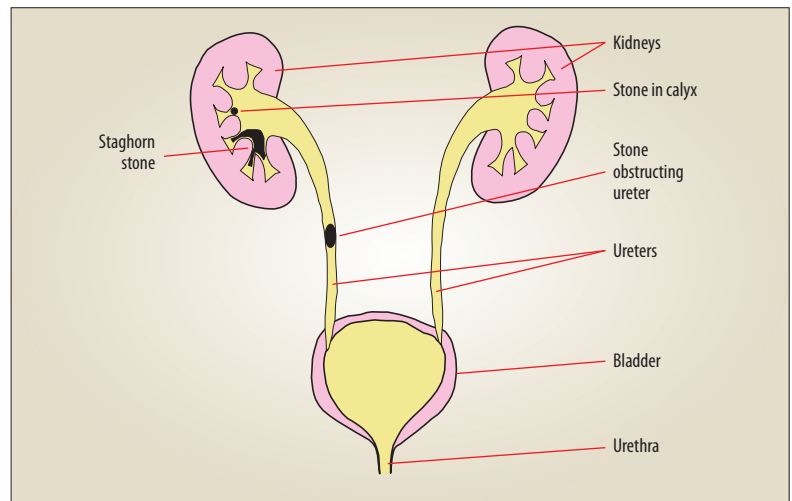
The location of the pain and its severity depend on how big the stone is, where it is located and also whether it is causing some obstruction to the flow of urine from the kidney to the bladder. In addition, the smooth muscle in the ureters may spasm, causing pain. Pain radiates to the loin area or, if the stone moves into the ureter, it may radiate down into the groin and the genitals. If the stone moves further down and lodges in the bladder–ureter junction, then there may be urinary symptoms, such as frequency and urgency. If infection is present, this will aggravate symptoms, as there may be fever and sepsis. However, if the kidney is completely obstructed there may be no pain or haematuria at all. Some stones are asymptomatic and only discovered coincidentally while investigating other conditions.

Investigations

Investigations will determine if there is a stone and eliminate any other conditions with similar symptoms (see Box 2). Stones are usually confirmed using imaging. Non-contrast CT has been found to be highly sensitive in evaluating up to 97% of ureteral obstructions and stones, and is now the imaging method of choice. Other tests (see Table 1) determine the presence of infection and kidney function. Stone analysis may be indicated, especially for recurrent stone-formers. Fluid input and output should also be measured to assess fluid intake and urine volume.

Treatment

Most stones pass spontaneously, although this may take some time; only 20% of patients usually require



■ Figure 1. Types of kidney stone

Box 2. Conditions with similar symptoms to kidney stones

- Biliary colic
- Aortic aneurysm
- Pylonephritis
- Acute pancreatitis
- Acute appendicitis
- Perforated peptic ulcer
- Epididymo-orchitis or torsion of testis
- Back pain

hospitalisation. Stones smaller than 4 mm in size have an 80% chance of passing spontaneously, while those larger than 6 mm only have a 20% chance. Patients can be managed at home with analgesia, while being carefully monitored for the passage of the stone and to ensure no sepsis or blockage occurs. Hospitalisation depends on the severity of the symptoms and should be considered if the patient has a fever, has only got one kidney, cannot tolerate oral fluids, has a known non-functioning kidney, has very low or no urine output, or has pain that cannot be controlled with analgesia. If there is any sign of kidney obstruction or sepsis, the patient will need emergency referral to a urologist for assessment and further investigation and treatment. If the stone does not pass spontaneously, the patient will need further imaging and possibly surgical treatment. Small stones that do not cause symptoms may be left untreated, but should be monitored for signs of enlargement, blockage and sepsis.

Pain relief

Patients need immediate pain relief. Non-steroidal anti-inflammatory drugs (NSAIDs) such as diclofenac are the drugs of choice if not contraindicated – which can be the case if the patient has a peptic ulcer, for example. Diclofenac is usually given rectally as it is thus absorbed rapidly. NSAIDs have been found to be effective and have fewer side-effects than opiates. Alpha-blockers such as tamsulosin relax ureteric

Table 1. Investigations for kidney stones

Test	Test type	Indication
Urine tests	<ul style="list-style-type: none"> • Dipstick and microscopy and culture • 24-hour urine 	<ul style="list-style-type: none"> • Detecting infection, detecting haematuria • Assessing calcium, oxalate, phosphate, citrate, urate, sodium and creatinine
Blood tests		<ul style="list-style-type: none"> • Assessing serum electrolytes, creatinine, urea, calcium and phosphorus for kidney function • Assessing dehydration and metabolic risk of future stone formation
Imaging	<ul style="list-style-type: none"> • CT scan • Ultrasound • Intravenous pyelogram • Retrograde ureteric studies 	<ul style="list-style-type: none"> • Diagnosis (especially in first-time stone-formers) • Detecting hydronephrosis, ureteral dilatation • Diagnosis of stone and obstruction • Confirm diagnosis if undetermined by X-ray
Nuclear studies	<ul style="list-style-type: none"> • MAG3 • Dimercaptosuccinic acid 	<ul style="list-style-type: none"> • Assessing kidney function (especially for large stones such as staghorn calculi)

Box 3. Dietary risk factors for kidney stone formation

- Low fluid intake
- High intake of animal protein
- High salt (sodium) intake
- High intake of excessive or refined sugars
- High intake of oxalate-rich foods
- Grapefruit and apple juice and cola soft drinks

muscle, relieving pain and aiding passage of the stone, as do calcium channel blockers such as nifedipine. Stronger analgesia such as opiates may be necessary if the pain does not subside.

Nausea and vomiting

Anti-emetics and intravenous fluid replacement may be necessary. If the patient is not nauseated and is able to drink, then increased oral fluid intake (2–3 litres) should be encouraged.

Extracorporeal shockwave lithotripsy

Extracorporeal shockwave lithotripsy (ESWL) treatment is usually an outpatient procedure; it is the treatment of choice for fragmenting stones smaller than 2 cm in diameter. It can also be used for ureteric stones. Energy waves are directed towards the stone and break it apart. This allows the smaller particles to pass spontaneously. ESWL is not suitable for pregnant patients or those with an aortic aneurysm.

Surgery

If there is any sign of an obstructed or septic kidney or possibility of a blockage occurring, then a nephrostomy tube (inserted into the kidney via the flank) or a stent (inserted up the ureter during a ureteroscopy) is needed to drain the kidney and to halt further damage. This procedure may also be performed as a precaution if the patient has a single

functioning kidney or if the pain is intractable. Small stones can be extracted using a 'basket' attachment on a flexible nephroscope that is passed into the bladder urethrally and then up into the ureter during a ureteroscopy. Larger stones can also be fragmented using lasers via the nephroscope. Laser fragmentation is the treatment of choice for obese patients and those with cystine stones or large stones that cannot be extracted using the basket. A ureteric stent is put down the ureter to ensure it remains patent after the trauma of the extraction.

If the stone is too large to be fragmented by laser, then it can be removed via a percutaneous nephrolithotomy. A nephroscope is put into the pelvis of the kidney via a nephrostomy in the patient's flank and the stone is fragmented and extracted.

If endoscopic methods do not work, then open surgery (nephrolithotomy) may be the only option. However, open surgery tends to be reserved for complex cases.

Preventing recurrence

Stone-formers should be advised to adopt some preventive measures to reduce the possibility of recurrence (see Box 3 for dietary risk factors).

Fluid intake

Increasing fluid intake to at least 2–3 litres a day not only prevents stones forming, but may delay and reduce recurrence by up to 50%. Increasing fluid intake dilutes the concentration of calcium, oxalate and uric acid, thereby reducing the supersaturation of urine by calcium oxalate, calcium phosphate and uric acid. It also clears out any crystals that have formed.

The type of fluid is also important. Tea and coffee have a high oxalate content, but as they have a diuretic effect, they actually have been found to reduce the risk of calcium oxalate stones by 10–14%. Beer and wine have a similar effect. However, patients who produce uric acid stones should avoid beer, as the high purine content increases the excretion of urate. Drinking a large quantity of soft drinks also increases the risk of calcium and uric acid stones, due to the high level of sugar and phosphoric acid.

Conversely, certain drinks can increase urinary citrate, which in turn reduces the risk of stone formation. Drinks such as lemon, lime and cranberry juice have this quality, although the high sugar content is a negative factor. Apple and grapefruit juice, however, have the opposite effect and have been found to increase stone risk.

Diet**Calcium**

A low-calcium diet is not recommended. Stone-formers on low-calcium diets have double the recurrence rate of those on normal diets. Low calcium

intake leads to calcium being leached out of the bones and back into the circulation. It also increases the intestinal absorption of oxalate, which results in higher oxalate excretion. This oxalate will then bind with the reabsorbed calcium and form more stones.

A high salt intake also results in higher calcium levels, as well as high urine pH and low urinary citrate levels. Dietary supplements of vitamin C also increase urinary oxalate excretion, and should be discouraged.

Oxalate

Reducing oxalate-rich foods (see Box 4) does not necessarily reduce formation of calcium oxalate stones, as it is the amount of oxalate the body produces that is thought to be the main cause.

However, eating oxalate-rich foods can add to the levels of oxalate excreted by patients with hyperoxaluria. Therefore, lowering intake may reduce the risk of stones in these patients – as well as those with diseases such as Crohn's disease or short bowel syndrome, which also result in high levels of oxalate.

Oxalate stone-formers may also benefit from reducing their intake of animal protein and salt. High animal protein results in increased intestinal absorption of calcium and bone resorption. It also increases the amount of oxalate absorbed and stimulates an increase in uric acid, with a drop in pH making the urine acid. Conversely, fruit and vegetables protect the body, due to their high water, potassium and magnesium content and the fact that they turn urine alkaline. Stone formation among vegetarians is half that of the non-vegetarian population.

Obesity and metabolic syndrome

Obese patients or patients with a high refined carbohydrate intake and high body mass index are

Box 4. Oxalate-rich foods

- Chocolate
- Celery
- Rhubarb
- Berries (strawberries, blackberries and so on)
- Nuts
- Plums
- Black tea
- Cocoa
- Spinach
- Parsley
- Leeks
- Green beans

more likely to have high urinary uric acid and sodium excretion and a low urine pH, which means they are at risk of forming stones. Unfortunately, having bariatric procedures such as gastric banding affects bile circulation in the body and results in loss of calcium. This results in an increase in oxalate absorption and so increases the risk of stones forming. Similarly, patients who have metabolic syndrome also have lowered urinary pH, as the kidney's ability to maintain the acid–base balance is impaired. Urine becomes supersaturated with uric acid and a low citrate level, so the risk of uric acid stones and urate calcium oxalate stones increases. Insulin resistance seems to be the key. Stone-formers have been found to be 20% more likely to be hypertensive than the general population; they are 33% more likely to suffer from myocardial infarction and have a 34% higher risk of stroke. Thus, diagnosis of stones may be an early warning sign of potential problems with diabetes, blood pressure and heart disease.

Research has shown that the Dietary Approaches to Stop Hypertension (DASH) diet, which promotes a Mediterranean type of diet with higher consumption of fruit, vegetables, nuts, whole grains and a lower consumption of sweetened drinks and red and processed meats, was found to increase urinary citrate and urine volume and so reduce the risk of calcium oxalate and uric acid stone formation.

Exercise

Exercise protects against stone formation as it reduces risk factors such as hypertension and insulin resistance. Socioeconomic status may also affect stone formation, as those with lower status have been found to have less healthy diets that are high in refined carbohydrates, fat and salt, which predispose to stone formation. Health promotion and education on the importance of eating a healthy diet and exercise are therefore important, especially in children, to combat the increasing obesity epidemic and associated stone disease ■

Declaration of interest
None declared.

Further reading

1. www.patient.co.uk/health/Kidney-Stones.htm (last accessed 18/09/12)
2. www.uroweb.org/fileadmin/user_upload/Guidelines/Urolithiasis.pdf (last accessed 18/09/12)
3. www.baus.org.uk/AboutBAUS/publications/stones-guidelines (last accessed 18/09/12)

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Key points

- Increased fluid intake (2–3 litres a day) is vital to prevent kidney stone formation and recurrence.
- A low-calcium diet may increase stone formation risk. A normal calcium diet is recommended, even for calcium stone-formers.
- A healthy diet high in fruit, vegetables, nuts and wholegrains may protect against kidney stone formation and recurrence. Diets that are high in refined carbohydrates, animal protein, fat and salt should be avoided.
- Stone-formers should be encouraged to adopt lifestyle changes to prevent recurrence.
- Having a renal stone may be an indication that there is an underlying problem, such as hypertension or diabetes, and ideally stone-formers should be managed using a multidisciplinary approach.