Renal stone disease

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Abstract

Renal stone disease (urolithiasis, nephrolithiasis) covers many conditions causing kidney, ureteric or bladder stones. These include metabolic and inherited disorders, anatomical defects of the upper or lower urinary tract, and chronic urinary infection. However, most cases of renal stones are idiopathic. They present with loin or abdominal pain, and visible or non-visible haematuria; this is followed by eventual passage of a stone and resolution, or the need for further investigation and intervention. Renal stones often recur and it is important to identify the underlying cause, particularly as stones can be related to diet and lifestyle, and are often associated with hypertension or diabetes. Although clinical management is largely surgical and may seem simple, the increasing prevalence of renal stone disease in Western society is becoming a significant economic and health burden.

Keywords Calcium oxalate; calcium phosphate; cystine; diet; infection; metabolic screening; stones; uric acid

Prevalence and epidemiology

Renal stone disease is common; in the UK about 8% of men and around 4% of women will form at least one stone by the end of their sixth decade. Urolithiasis is more common in affluent, industrialized countries than in poorer countries with agrarian economies. The prevalence is also rising in most countries.

Populations that consume diets rich in animal protein (meat, fish and poultry) have a higher risk of stones than those with a more vegetarian diet. The risk of forming a stone is increased further by a high intake of refined sugar, salt (which increases urinary calcium excretion) and oxalate-rich foods. A low intake of fluid, with or without a high ambient temperature, increases the risk of forming stones by increasing the concentration of stone-forming salts and acids in urine. Stone formation tends to recur; without preventative measures after a first stone about 25% of sufferers return within 5 years with at least one further stone.[1]

A positive family history of kidney stones is also an important risk factor; it is present in up to 50% of stone-formers, and first-degree relatives of stone-formers are twice as likely to have or develop a stone. A strong genetic influence on the excretion of calcium, oxalate, uric acid and citrate is very likely. Several genes have been implicated or investigated as possible contributors to 'idiopathic' kidney stone risk.[2]

Kidney stone disease is associated with systemic conditions such as diabetes mellitus, high blood pressure, chronic kidney disease and cardiovascular disease.[3–5]

Pathophysiology of stone formation

The salts and acids that normally crystallize in kidney stones do so because of their relative insolubility in urine. The most insoluble is calcium oxalate (CaOx); once a CaOx stone is trapped in the urinary tract, it is almost impossible for it to re-dissolve. Its solubility is independent of urinary pH, unlike the solubilities of other common stone constituents such as cystine and uric acid (soluble in alkali) or calcium phosphate (CaP) and magnesium ammonium phosphate (soluble in acid). However, the latter occurs only in the presence of infection involving a urea-splitting bacterium that produces high levels of ammonia (and ammonium ions, NH_4^+) and an alkaline environment.

The various urinary risk factors associated with stone formation are shown in Figure 1. For calcium-containing stones the risk factors are a low urine volume, a raised urine pH (>6.2), hypercalciuria, mild hyperoxaluria, hyperuricosuria, hypocitraturia (Table 1), and low urinary magnesium excretion.[6,7]

Clinical presentation

Symptoms and signs

Presentation can vary from asymptomatic — detected incidentally on a plain X-ray, ultrasound or CT scan requested for another reason — to intensely painful with typical and localizing renal or ureteric colic, back or abdominal pain, plus visible or non-visible haematuria and graveluria. Classical renal or ureteric colic pain rises to a crescendo, causing the patient to writhe around, unable to find a comfortable position. The pain can radiate to the groin and genital region, depending on the location of a stone, and be accompanied by nausea and vomiting.

A patient with colic from an obstructing stone typically presents with sudden onset of acute loin pain, often at night when the urine is maximally concentrated.

Investigations

Urinalysis

Urine analysis by dipstick in a patient with renal colic from a stone usually shows the presence of blood and protein and may be positive for leucocytes, even in the absence of infection. However, in up to 15% of patients dipstick is negative and it cannot exclude a stone. Sometimes stone-forming crystals can be seen in the urine on microscopy.

An associated urinary tract infection should always be considered, especially if urine dipstick is nitrite positive, and a mid-stream urine (MSU) sample sent for culture. Infection in the presence of an obstructing stone is potentially serious; it must be treated promptly with antibiotics and the patient referred for urological management.

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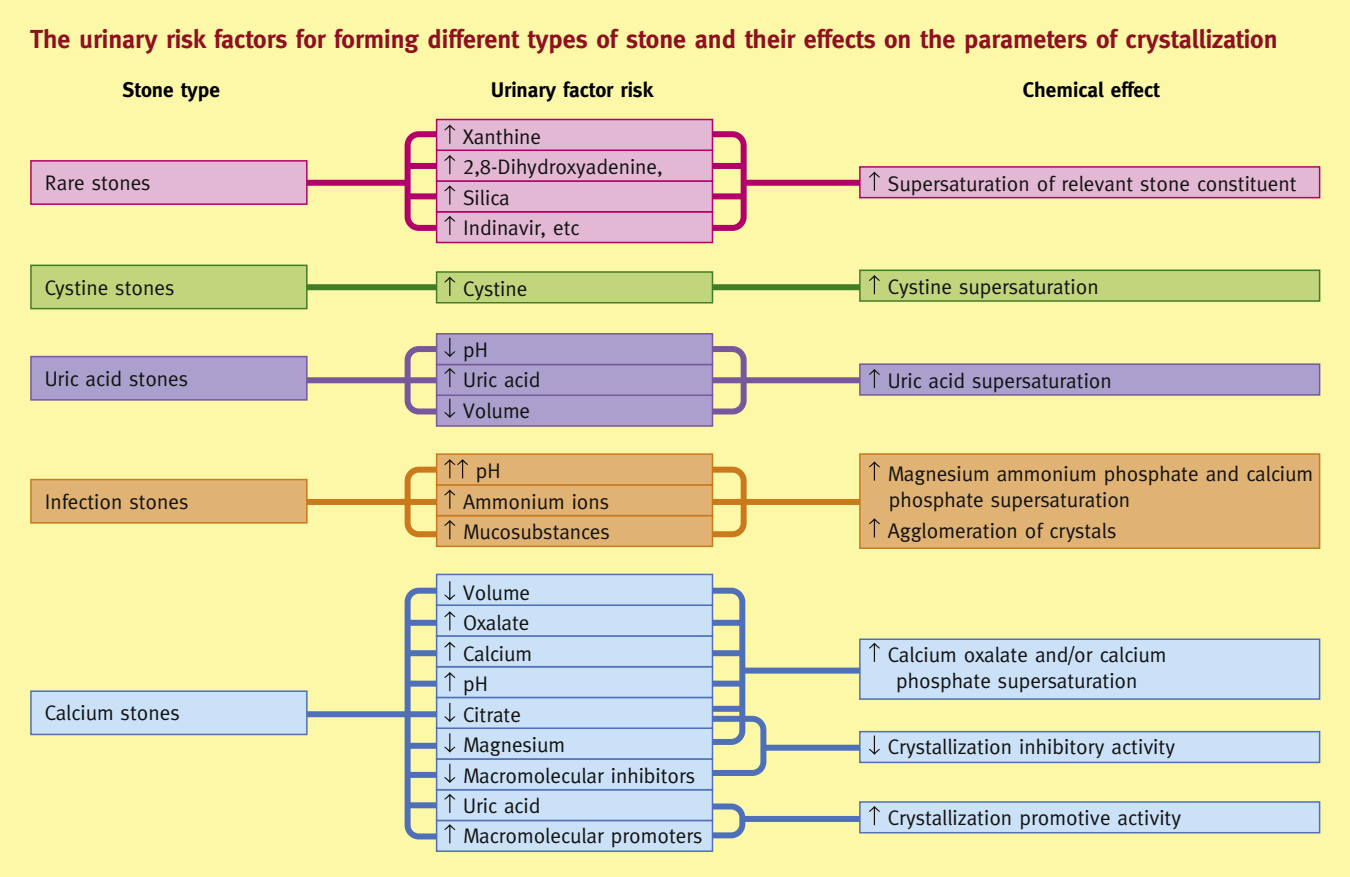

Figure 1

Imaging

Kidney-ureter-bladder (KUB) X-ray: urinary calculi that are rich in calcium are radio-opaque. Stones containing calcium phosphate are usually the most radio-opaque with a density similar to bone. Magnesium ammonium phosphate (struvite) stones are less radio-opaque than calcium phosphate stones. Radiolucent stones include pure cystine or uric acid, xanthine, dihydroxyadenine, indinavir, triamterene, and matrix (infection). These stones are often missed on a plain abdominal X-ray (KUB), but are easily seen (as radio-opaque) on a non-contrast CT scan (with the exception of indinavir and related protease inhibitor stones, and some matrix stones, which owing to their gelatinous nature and relative lack of calcium, remain radiolucent).

Ultrasound scanning: this is a useful non-invasive method of detecting kidney stones, but it is operator dependent and can over-diagnose renal stones. Ultrasound also has a high false-negative rate for identification of ureteric stones, which restricts its utility in an acute episode (see below under CT-KUB). It can detect the presence of hydronephrosis, and the use of colour Doppler can demonstrate an increase in resistive index in an obstructed kidney, as well as asymmetry or absence of ureteric (expulsed urine) 'jets'; however, these features do not always reliably diagnose obstruction, which may require an intravenous urogram or dynamic (radionuclide) renogram scan. Ultrasound scanning is a useful screening method when following patients with a history of recurrent stones and avoids the need for multiple CT scans and the potential cumulative radiation risk. In a randomized trial, the diagnostic accuracy of ultrasound was similar to that of a CT scan in diagnosing patients with suspected stones in an acute setting.[8]

Intravenous urography (IVU): the administration of intravenous contrast media is still a useful investigation in diagnosing

Normal range of urinary excretion of important stone constituents and stone risk factors

Urinary constituent	Normal 24-hour excretion (mmol)
Calcium	2.5–8 (men) 2.0–6.0 (women)
Oxalate	0.15–0.45 (1.0–3.0 in primary hyperoxaluria)
Uric acid	2.0–5.5 (men) 1.5–5 (women)
Citrate	0.5–5 (men) 1.0–5.0 (women) (<0.5 in distal renal tubular acidosis)
Cystine	<0.01 (0.5–3.0 in cystinuria)

Table 1